FUNGI

VOL. XXIV

by

STANISŁAW BAŁAZY

MYCOTA (GRZYBY)

INTERNATIONAL
MYCOLOGICAL INSTITUTE
LIBRARY

28 FEB 1995

EGHAM \ F

POLSKA AKADEMIA NAUK
INSTYTUT BOTANIKI im. W. SZAFERA

FLORA POLSKA

(Flora of Poland)

GRZYBY (MYCOTA)
tom XXIV

OWADOMORKOWE
ENTOMOPHTHORALES

opracował
Stanisław Bałazy

ERRATA

[S. Bałazy – Fungi. T. XXIV. Entomophthorales. Kraków 1993]

page 23, insert a supplement to the explanation under fig. 8
„h-i *Entomophaga spp.*: h – common pear–shaped, i – elongate secondary conidium of *E. tipulae*"

page 46, line 40, for „Mande" read „Manole" (done twice)

page 96, line 31, for „adults" read „adult"

page 102, line 7, for „capaniform" read „campaniform"

page 105, line 16, for „perturbance" read „protrusion"

page 215, in explanation under fig. 39d, for „a larvae of cantharid beetle larva" read „a larva of cantharid beetle"

page 225, line 6, for „illustoation" read „illustration"

page 250, line 8, for „***Tarichium.*** **C o h n**" read „***Tarichium*** **C o h n**"

page 284, line 41, for „komórki" read „jądra"

POLISH ACADEMY OF SCIENCES
W. SZAFER INSTITUTE OF BOTANY

FLORA OF POLAND

(Flora Polska)

FUNGI (MYCOTA)
vol. XXIV

ENTOMOPHTHORALES

by

Stanisław Bałazy

CAB INTERNATIONAL
00119158

Redaktor: prof. dr A. Skirgiełło

Komitet Redakcyjny:

Janusz Nowak (Kraków), Jadwiga Siemińska (Kraków),
Alina Skirgiełło (Warszawa) – Redaktor

Skład komputerowy i opracowanie techniczne

Anna Wyrostek

WYDAWNICTWA INSTYTUTU BOTANIKI PAN KRAKÓW

ISBN 83-85444-26-2

© Copyright by Instytut Botaniki im. W. Szafera, PAN
Kraków 1993

INTRODUCTION

The order of *Entomophthorales* comprises saprophytic as well as phyto- and zoopathogenic fungi, however, among the species known to date the latter are decidedly dominating. The most numerous group among them are arthropod pathogens. Hence comes the Latin name of the order (the Polish equivalent being its exact translation), since the first species to be described within it were forms causing insect diseases (Gr. εντομον — terrestrial arthropod, mainly insect, φυωρα — pest, pestilence). It was Fresenius (1856) who used for the first species described in this group the generic name *Entomophthora*, instead of *Empusa* applied earlier by Cohn (1855). Fresenius rightly considered *Empusa* to be already in use in the botanical nomenclature, since it had been used for orchids by Lindley (1824). In the course of the century there arose much confusion and ambiguity around the nomenclatural problems. They impeded the development and progress in research on the biology and taxonomy of the entomophthorales, and they still have not been solved completely.

Although these fungi have been the subject of great interest ever since they were first discovered, and very numerous references concerning them have appeared, there is at present no comprehensive monograph of the order. Towards the end of the 19th century such a role was filled for the North American species by Thaxter's (1888) paper. Lakon (1919) compiled and partially supplemented information on the entomopathogenic taxa recognized till the second decade of this century. Neither of these papers contained keys for the species identification. The first monographs containing comprehensive keys did not appear until the second half of the 20th century (Hutchison 1962, Srinivasan & Thirumalachar 1967, MacLeod & Müller-Kögler 1970, 1973, Soper 1974, Waterhouse 1975, MacLeod et al. 1976, King 1976 a,b, 1977, Waterhouse & Brady 1985). In the mid 1960's Batko (1965) compiled a key for the Polish species, based on the results of his studies on the biology and taxonomy of this fungus group. His key has not been published, however. A series of papers by this author (Batko 1964 b,c,d,e, 1966 a,b) and particularly his treatment of the phylogenesis and taxonomy of *Entomophthoraceae* (Batko 1974a) broke the conservative position concerning the nomenclature within the order and advanced work aiming to assess characteristics as the criteria for the separation of taxa into determined ranks (Remaudière & Hennebert 1980, Remaudière & Keller 1980, Humber 1981, Humber & Ben-Ze'ev 1981, Ben-Ze'ev & Kenneth

1982, Ben-Ze'ev et al. 1987). At present most problems in the systematics concern the determination of feature criteria in the species rank and intraspecific taxonomy (Ben-Ze'ev & Kenneth 1982, Bałazy 1984, 1986, Humber 1986). These considerations eliminated numerous errors in the systematics and nomenclature of these pathogenic species and led to a better understanding of the biology — in particular, the specificity of the host-pathogen relationship. Recently they led to the publication of regional keys for species identification based on modern taxonomic criteria (Humber & Ben-Ze'ev 1981, Humber et al. 1986, Keller 1987, 1991). Simultaneously studies on non-entomopathogenic entomophthorales have been continued (Srinivasan & Thirumalechar 1967, King 1976 a,b, 1977, Coremans-Pelseneer 1976, Tucker 1981). Except for the genus *Conidiobolus* Brefeld, though, other taxa have still been rather poorly studied.

The entomophthoralean fungi of Poland have been rather intensively investigated. German mycologists from the strong Silesian research center in Wrocław, begininng with the description of the first entomopathogenic species by Cohn (1855), continued regional recognition of these fungi in the second half of the 19th century, discovering new taxa both entomopathogenic and non-entomopathogenic (Cohn 1870 a, Eidam 1886, Schroeter 1886). The part of Schroeter's collection concerning *Entomophthoraceae* deposited in the Wrocław Botanical Garden Herbarium has been reviewed during the present study. The contribution of Poles to studies of the biology, taxonomy and practical significance of the entomophthorales has also been considerable, especially in regard to the entomopathogenic species. Soon after the description of the first species, Nowakowski (1877) examined their development. He determined correctly their alliance to *Zygomycetes* contrary to the view of Brefeld (1867), who tried to classify them among the basidiomycetes as close to *Ustilaginales*. The same author (Nowakowski 1977, 1883) described several species new to science from Central Poland. By the end of the 19th century there were important contributions to the karyology and development of *Basidiobolus ranarum* by Raciborski (1896, 1897, 1910), who also described one entomopathogenic species of the family *Entomophthoraceae*. A few Polish researchers participated in the Russian investigations concerning the possibilities of practical use of some pathogenic fungi — including entomophthoralean species — for pest control. After the liberation, these fungi were treated in the studies of many mycologists and phytopathologists, among them L. Garbowski, Z. Mokrzecki, M. Boczkowska, W. Konopacka, J. and W. Siemaszko, and, after the Second World War, A. Batko, I. Majchrowicz, S. Bałazy, R. Miętkiewski and others.

Unfortunately, materials preserved in herbaria are rather scarce. Besides the aforementioned collection of the Botanical Garden at the Wrocław University (WRSL), a few specimens were found in the Herbarium of the Department of Plant

Systematics and Phytogeography at the Warsaw University (WA) and in the Herbarium of the Institute of Botany of the Polish Academy of Sciences in Kraków (KRAM). The discovery of single specimens scattered in other botanical or mycological collections may be expected. All materials from these herbaria, were thoroughly studied by the author. Contemporary collections made in Poland since the 60's mostly by the author and some collabotators served principally as the basis for this review. They are all deposited in the mycological collection of the Research Center for Agricultural and Forest Environment of the Polish Academy of Sciences in Poznań, Poland (ZBS PAN).

The purpose of this work is to present the state of knowledge of the entomophthorales in Poland against the background of world progress in the research on this group, to orient the reader to the morphology and species diversity within the higher taxa, and to facilitate the identification of obtained strains in agreement with the modern taxonomical rules. Since most of the species currently known in Poland have also been reported from other countries and continents the present work contains species which have not yet been found in Poland but which may be expected. It should be noted that currently known entomophthoralean species in all appearances make up only a small part of the true diversity of these fungi. Further studies will no doubt lead to the description of numerous new species or even higher taxa. Continuous supplementation and modifications of the actual systematic arrangement will need to be made.

For various reasons, in recent years, the work on this review could not be the author's only occupation. Hence particular strains, species and genera have been treated with differing degrees of detail and precision depending on the abundance of material and possibilities to carry out analytical studies. Some keys have been compiled by adapting papers and descriptions published previously by other mycologists to the arrangement applied in this book. The author is aware that there are omissions and necessary simplifications as well as some insufficiently justified, controversial or simply doubtful statements, which should be clarified in further studies. The author's decision to prepare this review was guided mainly by the necessity to merge the principal and essential information on the entomophthoralean fungi and to present it in the form of relatively clear keys for identification. This should both facilitate the diagnostics for practical use and help to direct further investigations towards controversies or ambiguities in the taxonomy, ecology and physiology of these fungi.

It was Professor Dr. Alina S k i r g i e ł ł o who encouraged the author to undertake this review and to bring it to an end. The author expresses his sincere gratitude for her precious advice and patience. He is also indebted to Professor Dr. Andrzej B a t k o (Warsaw University, Department of Plant Systematics and Phytogeography) and Professor Dr. Tomasz M a j e w s k i (Agricultural University

of Warsaw, Chair of Plant Pathology) for their critical review of the manuscript, corrections, valuable suggestions and editorial remarks.

The author wishes to express his gratitude to all who through their kind remarks, advice, materials and help in obtaining references or unpublished information, allowed him better to present the taxonomical problems of this group of fungi; in particular to: Professor Dr. Andrzej Batko (Warsaw University), Dr. Israel Ben-Ze'ev (Hebrew University of Jerusalem, Department of Plant Pathology and Microbiology, Israel), Olga Brzezińska-Gabler, M.S. and Lidia Charłampowicz (Library of the Institute of Plant Protection, Poznań, Poland), Dr. Jorgen Eilenberg (Royal Veterinary and Agricultural University, Department of Zoology, Copenhagen, Denmark), Dr. Richard Humber (USDA-ARS, Plant Protection Research Unit, Ithaca N. Y., USA), Dr. Siegfried Keller (Federal Research Station for Agronomy, Zurich, Switzerland), Professor Dr. Jerzy J. Lipa (Institute of Plant Protection, Laboratory of Biological Control, Poznań, Poland), Professor Dr. Irena Majchrowicz (Agricultural University of Szczecin, Department of Entomology, Poland), Professor Dr. Ryszard Miętkiewski (Agricultural and Teacher's University, Department of Plant Protection, Siedlce, Poland), Dr. Bernard Papierok (Institut Pasteur, Biological Control Research Unit, Paris, France), Dr. Richard Soper (USDA, Insect Pathology Research Unit, Ithaca N. Y., USA), Dr. Kuniyoshi Takeuchi (Yamanashi University, Department of Civil and Environmental Engineering, Takeda-4, Kofu, Japan), Dr. Elena Voronina (Institute of Plant Protection, St. Petersburg, Russia).

The author would also like to thank the following persons for their kind help in the collection of material and for allowing access to their materials: Dr. Edward Baraniak and Professor Dr. Zdzisław Bogucki (A. Mickiewicz University in Poznań, Poland), Barbara Dembowska M. S. (Poznań, Poland), Dr. Lesław Gralicki (Poznań, Poland), Dr. Jerzy Gutowski (Forestry Research Institute, Division of Białowieża), Engineer Wanda Hoffman (Wielkopolski National Park, Puszczykowo), Dr. Magdalena Jaworska (Agricultural University of Kraków), Professor Dr. Zofia Machowicz-Stefaniak (Agricultural University of Lublin), Professor Dr. Jacek Michalski and Professor Dr. Jerzy Wiśniewski (Agricultural University of Poznań), Professor Dr. Ryszard Miętkiewski (Agricultural and Teacher's University, Siedlce), Dr. Wanda Stojanowska (Wrocław University, WRSL Herbarium), Hanna Świeżyńska, M. S. (Forestry Research Institute, Warszawa).

Special thanks are due to Dr. Krista Stöcker (Halle, Germany) for her help in the reading of Professor F. Schroeter's autographic labels from the Herbarium of the Wrocław University (WRSL).

An important element of this study is an attempt to define precisely the systematic affiliation of the arthropod hosts of entomophthoralean fungi. The author

feels greatly obliged to those entomologists or acarologists who identified the insect or mite specimens sent to them or confirmed the author's identification: Dr. Jerzy Achremowicz (Agricultural University of Kraków, Department of Plant Protection), Roman Banaszak, M. S. (Agricultural University of Poznań, Chair of Forest Entomology), Dr. Edward Baraniak (A. Mickiewicz University in Poznań, Institute of Systematical Zoology), Dr. Agnieszka Draber-Mońko, Dr. Jakub Nowakowski, Professor Dr. Regina Pisarska and Professor Dr. Henryk Szelęgiewicz (Institute of Zoology of the Polish Academy of Sciences, Warszawa), Dr. Seweryn Grobelny (A. Mickiewicz University in Poznań, Department of the Bird Ecology), Dr. Jerzy Karg, Dr. Danuta Krzywiec and Dr. Danuta Szefińska (Research Center for Agricultural and Forest Environment of the Polish Academy of Sciences, Poznań), Dr. Alicja Korcz (Institute of Plant Protection, Department of Agricultural Entomology, Poznań), Dr. Wiktor Micherdziński (Jagiellonian University, Zoological Museum, Kraków), Professor Dr. Bartłomiej Miczulski (Agricultural University of Lublin, Institute of Plant Protection), Professor Dr. Jan Rafalski (A. Mickiewicz University of Poznań), Professor Dr. Jerzy Wiśniewski (Agricultural University of Poznań, Chair of Forest and Environment Protection).

The electron micrographs were kindly made by Dr. Lidia Zielińska and her collaborators in the Laboratory of Virology of the Institute of Plant Protection in Poznań.

The author also wishes to thank Mrs. Romana Lipońska, M. S., for preparing the Latin descriptions of new species; his sister Dr. Teresa Bałazy, and Miss Laurel Sherwood (USA), for help with the English version; Mrs. Barbara Pelko, M. S., and Mrs. Iwona Hołodyńska, for their assistance in preparing the manuscript and for careful corrections.

A considerable part of the research was carried out within the Research Programme CPBP-04.10.03. „Ecological guidelines of the agricultural landscape protection and management" co-ordinated by Professor Dr. Lech Ryszkowski, and the final investigations were brought to an end within the author's research project „Host selectivity and agressiveness as criteria for systematics and practical use of entomopathogenic fungi", financed by the Committee for Scientific Research (KBN).

GENERAL CHARACTERISTICS

The order *Entomophthorales* belongs to the class *Zygomycetes*. Apart from the process of gametangiogamy typical for the class as a whole a common feature of the species included here is the ability to produce conidia formed on simple or branched conidiophores, actively ejected from the conidiogenous cells. Unlike the hyphae of *Zoopagales* and *Mucorales*, the hyphae of *Entomophthorales* are usually divided by cross-walls on mono- or polykaryotic segments and often fragmented into separate cells called hyphal bodies.

Morphology and development

The vegetative mycelium of the entomophthoralean species is usually hyphal and relatively widely spread, or transformed into hyphal bodies of various shapes (Fig.1). The mycelium multiplies by fragmentation or by budding of the hyphae either inside the host's hemocel in pathogenic forms or in aqueous or semi-aqueous habitats in saprophytic forms. Particular cells of the thallus are poly- or oligokaryotic. Monokaryotic cells are only found in the hyphae and conidiophores of *Basidiobolus* spp. and in conidiogenous cells and the conidia of *Zoophthora* spp. and *Strongwellsea* spp. According to the present recognition both the differentiation of the structure of nuclei and their number in particular cells of the thallus and in the conidia are important characteristics for the systematics of the entomophthoralean fungi, often serving as criteria to separate taxa of a definite rank (Batko 1964 b,c,d,e, 1974, Humber 1976, 1981, 1989, Ben-Ze'ev & Kenneth 1982, Ben-Ze'ev et al. 1986). With regard to morphology and structure three basic types of nuclei can be distinguished.

Basidioboloid nuclei (Fig.2) are large, globose or ellipsoid, with a relatively large and distinct central nucleolus which stains well in common nuclear dyestuffs. Such nuclei are characteristic for the family *Basidiobolaceae*, in which monokaryotic cells usually occur both in the mycelium and in spores.

Ancylistoid nuclei (Fig.3) are small and are barely or not at all staining in common nuclear stains, which points to a small quantity of heterochromatin dispersed in the nucleoplasm. The nucleolus is small but distinct, usually centrally located. Nuclei of this type are characteristic for the families *Ancylistaceae* and *Meristacraceae*, and they occur usually in large numbers both in the hyphal bodies, in the hyphal segments, and — with some exceptions — in the conidia, so these structures are considered polykaryotic.

Entomophthoroid nuclei (Fig.4) are relatively large, spherical, ovoid or oblong. The nucleoplasm contains a large amount of condensed heterochromatin thanks to which such nuclei stain distinctly in common nuclear stains. They are charcteristic for the family *Entomophthoraceae* and occur in numbers of two to about 50 in particular cells, conidiophores and conidia, except in the conidiogenous cells and conidia of the genera *Zoophthora* and *Strongwellsea*, which are monokaryotic.

Recently, however, Ben-Ze'ev et al. (1987) distinguished two sub-types within the latter type of nucleus. The first is characterized by a greater amount of unevenly condensed heterochromatin showing distinct granular or rope-like aggregations in the nucleoplasm, and by a small metaphase karyokinetic spindle. This kind of nucleus is found in the family *Entomophthoraceae* s. str. The nuclei of the second type appear to have a smaller amount of evenly dispersed heterochromatin (weakly condensed areas are sometimes visible with an electron microscope), and the karyokinetic spindle in metaphase is centrally located, occupying most of the nuclear volume. Such nuclei are characteristic for the species of the genus *Neozygites* (Ben-Ze'ev & Kenneth 1986, Humber 1989), so they can consequently be called neozygitoid nuclei. Some additional characteristics and differences between these two types of nuclei are discussed in the above mentioned papers of Ben-Ze'ev et al. (1986) and Humber (1989). For practical reasons the new family *Neozygitaceae* proposed by these authors will not be distinguished in the present review.

The mycelium of saprophytic species is usually abundant and consists of long, branched, tubular hyphae, either divided by septa into monokaryotic (e.g. in *Basidiobolus*) or oligo- to polykaryotic segments, with more or less numerous crosswalls and with pseudosepta dividing sections deprived of protoplasm. A similar mycelium is produced by numerous entomopathogenic strains cultured in vitro. In parasitic species under natural conditions the vegetative mycelium develops inside the host and sometimes even only in certain parts of the host's body, so that only the conidiophores, and eventually other hyphae performing special functions, grow on the outside. The vegetative hyphae usually subject to fragmentation forming so called hyphal bodies, which can be shaped like elongated hyphal segments with irregular puffs or outgrowths and short branches, but are also often globose, ovoid, ellipsoid or ameboidally polymorphic (Fig. 1). They multiply inside the host's body by successive divisions or by budding. Their occurrence may be connected with the whole period of the disease or only with some of its phases. The formation of the hyphal bodies in submerged mycelia not infrequently takes place in artificial cultures as well as in many species considered to be non-pathogenic (King 1976, 1977). Many entomopathogenic species have been observed to form so called protoplasts, i.e. covered only by plasmolemma plasmatic granules of different shapes, liberated into the infected host hemocels. They begin to appear in the early phases of diseases, steadily growing and transforming into hyphal

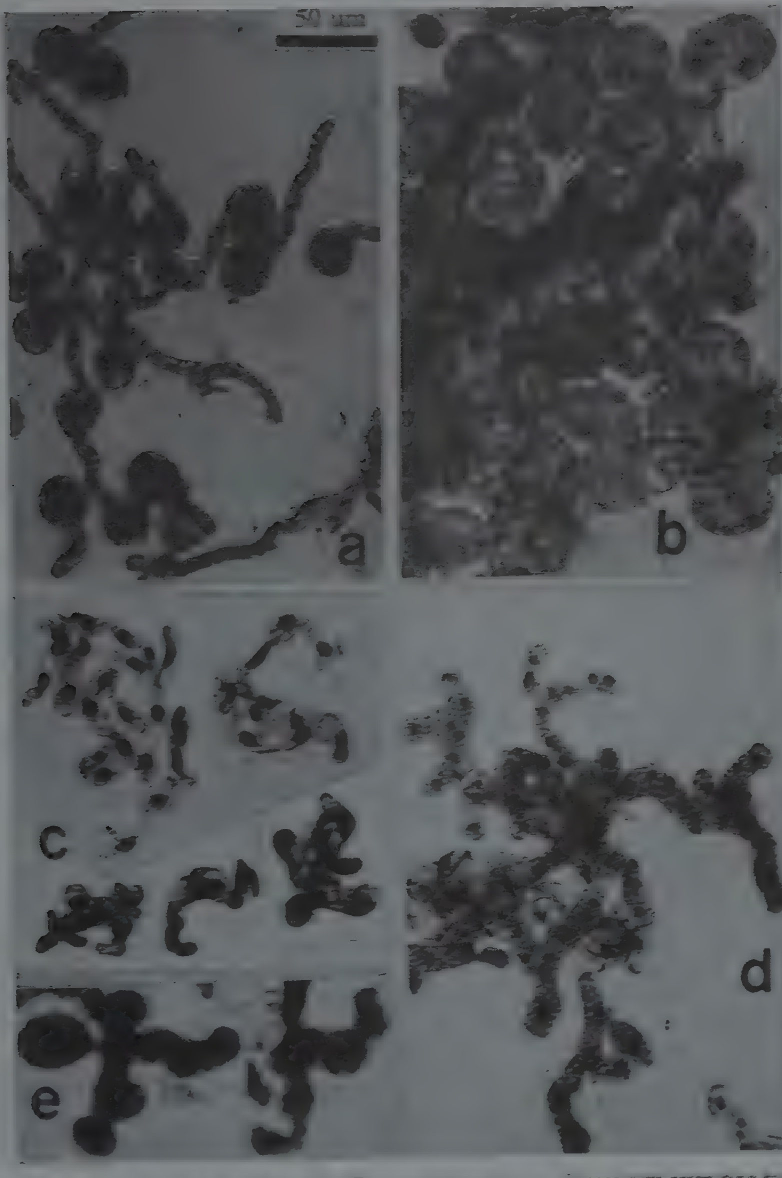


Fig. 1. Different types of hyphal bodies in [illegible]

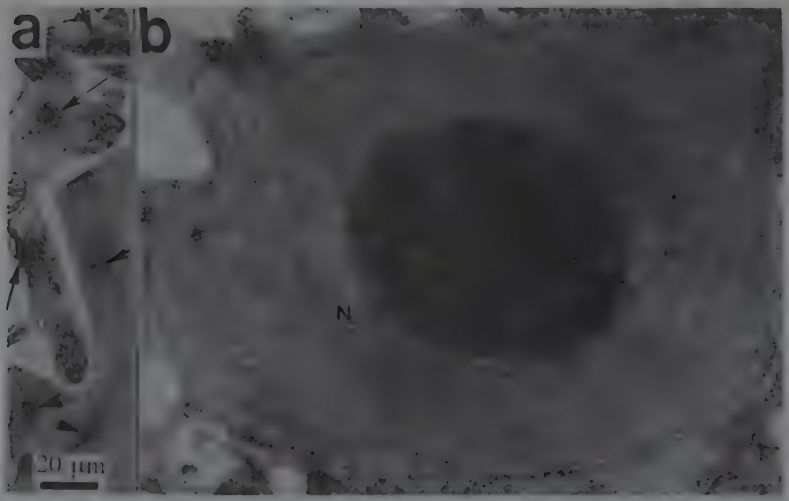


Fig. 2. Basidioboloid nuclei in hyphal bodies of *Basidiobolus ranarum*. a — stained by aceto-orcein in lactophenol (arrows), b — electron microphoto 15000x (N — nucleus).

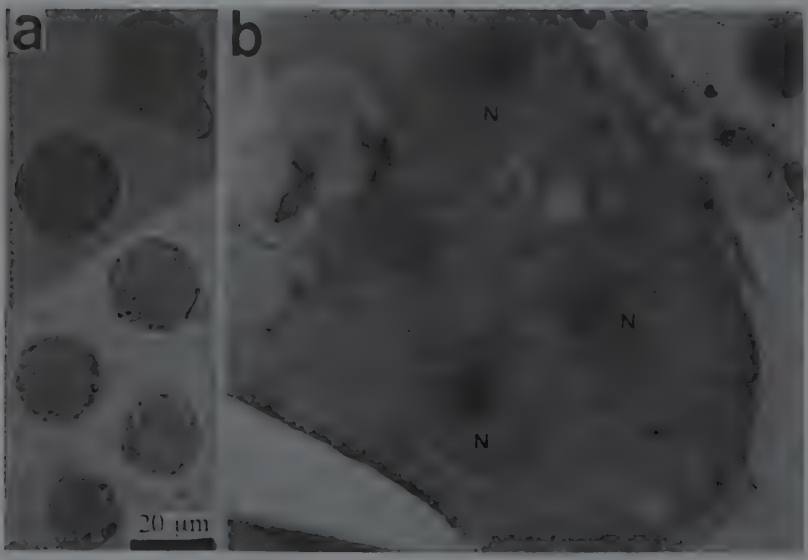


Fig. 3. Ancylistoid nuclei: a — in primary and secondary conidia of *Conidiobolus coronatus* weakly stained by aceto-orcein, b — in hyphal bodies of *Conidiobolus thromboides*, electron microphoto 15000x (N — nuclei).

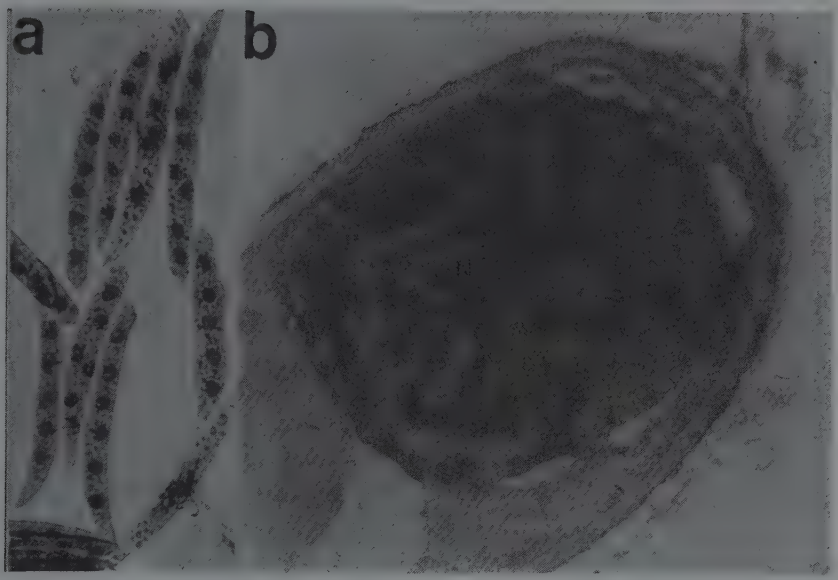


Fig. 4. Entomophthoroid nuclei: a — in primary conidia of *Eryniopsis longispora* stained by aceto-orcein, b — in a hyphal cell of *Zoophthora* subg. *Neopandora* sp. from a plant hopper, electron microphoto 15000x (N — nucleus).

bodies. Such protoplasts are able to grow and multiply, and when injected into healthy insects, they cause typical disease symptoms (Tyrrell & Mac Leod 1972). A number of species also produce protoplasts in artificial liquid media (Humber 1981, 1989). Hyphal branches morphologically undifferentiated or uneven in size, as well as particular hyphal bodies, may function as gametangia, conjugating directly or through lateral protrusions on neighbouring hyphae. A zygote formed as a result of the conjugation is surrounded by a thick two- or three- layer wall and performs the role of a resting spore, called the zygospore. Benjamin (1962) described and illustrated cases of longituginal division of the primary conidia of *Basidiobolus microsporus* Benjamin, where each half of the spore functioned as the typical gametangium, conjugating and producing the zygospore. The shape, size, colour, wall thickness and surface ornamentation of the zygospores are usually characteristic for particular species (Fig. 5). Analogous structures as regards morphology and function are in many species formed apogamically from the hyphal bodies and segments of the hyphae (Fig. 20) and are called azygospores. In some environmental conditions this often happen to be the only form of sporulation of particular strains. When it is impossible to state and characterize any conidial sporulation — commonly accepted to be the basic feature for the systematics of *Entomophthorales* below the family rank — the strain

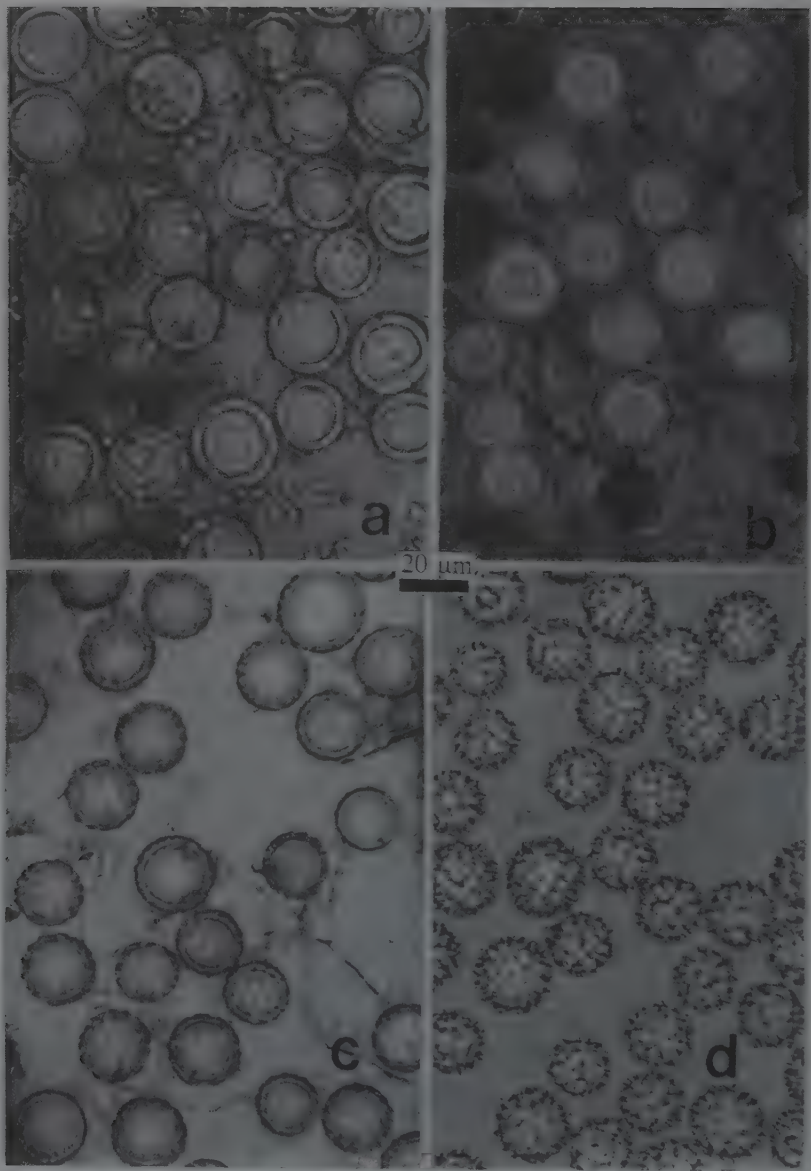


Fig. 5. Different types of resting spores in *Entomophthorales*: a — *Zoophthora* subg. *Zoophthora arginis*, b — *Basidiobolus ranarum*, c — *Tarichium* sp. from a plant hopper, d — *Zoophthora* subg. *Neopandora echinospora*; approximate magnifications.

Fig. 6. Conidiophores of *Entomophthorales*: a — *Zygnemomyces echinulatus*, b — *Eryniopsis longispora*, c — *Ballocephala sphaerosperma*, *d* — *Zoophthora* subg. *Zoophthora* sp., e — *Meristacrum milkoi*, f — *Basidiobolus ranarum*, g — *Entomophthora* sp., h — *Conidiobolus* sp., i — *Entomophaga* sp. (a — after Tucker, c — after Drechsler, e — after Couch, Andreeva, Laird and Nolan — simplified).

may be counted into the group at the generic level but without any systematical rank, under the name *Tarichium* Cohn (1870 b), artificially separated after the features of the resting spores of both the zygo- or azygogamic origin. Hitherto only zoopathogenic (or perhaps not pathogenic but zoophilic) strains have been treated in this way (Lakon 1919, MacLeod & Müller-Kögler 1970, Batko 1974, Humber 1989, Bałazy & Wiśniewski 1982, 1984, Bałazy et al. 1987).

As it has already been mentioned, the order of entomophthorales has been separated on the basis of similarity of forms of the conidial sporulation of its representatives. Despite certain controversies concerning the determination of sporulation types (Humber 1981, Latgé et al. 1986) it is the prevailing opinion that the conidial spores of the entomophthorales are variously transformed sporangia (Thaxter 1888, Alexopoulos 1962, Batko 1964 b,c,d, 1974, Kreisel 1967, Ben-Ze'ev & Kenneth 1982), produced on conidiophores or their branches. The conidiophores grow out as the branches of hyphae or directly from hyphal bodies. They may be similar to vegetative hyphae. More often, however, they differ from the latter in shape, thickness and the type of branching (Fig. 6). The morphology of the conidiophores contains significant taxonomical features. In the majority of species the conidiophores are unbranched, as terminal sections of relatively long hyphae growing endogenously within a host and perforating its cuticle or, in saprophytes, as branches of the vegetative hyphae. However, in some representatives of genera and species parasitizing in very small invertebrates or in plant cells (*Ancylistes*, *Completoria, Macrobiotophthora*), the conidiophores may grow directly from hyphal bodies as relatively thick, differentiated structures, furnished sometimes with lateral outgrowths or denticles on which the conidia are born (*Zygnemomyces*). In the genus *Meristacrum* the terminal part of the conidiophores divides successively by cross-walls in basipetal arrangement and the unicellular segments function as sporogenous cells. In *Ballocephala*, on the other hand, globose or ampulliform sporogenous cells grow sympodially on the terminal, nonseptate part of the conidiophore (Fig. 6c).

Several different types of conidial sporulation have so far been recognized depending on the structure of conidiophores, the morphology of conidia and particular mechanisms of their ejection. With a few exceptions discussed below, the common feature of these fungi is the ability to actively eject the conidia a certain distance from the conidiophore due to increased osmotic pressure in the apical part of the conidiogenous cell and in the ripening conidium. Generally, the effect of these phenomena is comparable to the principles of operation of some kinds of arms, hence sometimes they have been called ballistospores. Since this term was already introduced and applied for a particular type of spore ejection in some *Basidiomycetes* it shall not be adapted for the entomophthorales in this review. According to Batko (1974) the cause of spore discharge is analogous to hitting a ball, so

he has proposed the term „ballospore", which corresponds with the physiological mechanism causing projection of the spores (S n e l l & D i c k 1957). It has been accepted by the author. These mechanisms, differing as to particulars, have been observed to condition these phenomena. Since at least some of them are considered to be of importance in systematizing forms within the group under discussion it will be advisable to present them in more detail.

— Rounding off or papilla eversion is the simplest and simultaneously the most frequent case in *Entomophthorales*. It consists of a strong rise of the osmotic pressure in the spore and the terminal part of the conidiogenous cell, which leads to the breaking of the external wall in a place where the conidium joins the conidiogenous cell. As a result the thinner wall in the basal part of the conidium, called papilla, undergoes a sudden rounding off and the spore is ejected.

— Sporophore rocket — this type of conidium ejection has only been observed in the genus *Ballocephala*, and combined with the first type — also in *Basidiobolus*. In contrast to the previous type the breaking off of the conidium does not occur at its junction with the conidiophore but at the base of the sporogenous cell (*Ballocephala*) or a subapical turgoscent swelling of the sporophore (*Basidiobolus*). Thanks to this the conidium undergoes a transposition with jet force. Independently of this in *Basidiobolus* the jet force may be heightened by the rounding-off of the papilla.

— Sporophore cannon is the type of conidium ejection charcteristic for representatives of the genus *Entomophthora* F r e s. sensu R e m a u d i è r e et K e l l e r and for the species described under the name „*Entomophthora dysderci*" V i é g a s (1939). This last species, however, has been transferred to the genus *Batkoa* (H u m b e r 1989). At the time of conidium ripening the terminal part of the conidiophore is plunged deeply into the spore as a kind of columella. The breaking off of this columella at the moment of separation of the conidium leads to the ejection of the latter in a stream of a liquid content gushing under a considerable pressure from the conidiogenous cell.

There is a common opinion that the mechanisms of spore ejection have been retarded in the genera *Massospora* and *Zygnemomyces* where the conidia are passively detached. Such a position seems to be confirmed by similarities in the ontogenesis and thallus morphology, pathogenesis and histopathology (S o p e r 1964, 1972, H u m b e r 1981, T u c k e r 1981, B e n-Z e' e v & K e n n e t h 1982).

Most representatives of the entomopthorales are able to produce several different kinds of spores. Besides the already mentioned zygospores and azygospores acting as resting spores, chlamydospores are known particularly in saprophytic strains. Different types of conidia are produced as propagative sporulation. The above described types of spore ejection concern conidia primarily produced on the conidiophores or their branches and for this reason are called primary conidia. In

particular strains or species they are usually of identical structure and of a very similar shape and size. Therefore, important diagnostic features comprised in them often have the character of taxonomic criteria. Only in few hitherto known species may the primary conidia be essentially different in shape, e.g. *Eryniopsis caroliniana* (Thaxter) Humber and *Zoophthora* subg. *Erynia variabilis* (Thaxter) Batko, *Zoophthora* subg. *Zoophthora anhuiensis* (Li) Bałazy. The existing data concerning primary conidia of the entomophthorales seemed to indicate a correlation between the spore wall structure and the number of nuclei. The conidia with the one layer membrane (unitunicate according to Humber 1981) were two to many nucleate, whereas the conidia with two-layer walls (bitunicate) were always monokaryotic, if one overlooks sporadic abnormal cases. However, while investigating the ultrastructure of *Conidiobolus coronatus* (Costantin) Batko — the species which was counted into the first group on the basis of observation in the light microscope — Garrison et al. (1975) stated that its conidial wall consists in fact of two layers and the outer, thinner one, is lacking on the papilla, similar to in the species of the second group. As a result of electron microscope studies of the wall structure of three species of the genus *Entomophthora* Fres. sensu Remaudière et Keller, Eilenberg et al. (1986) observed that the hyphal bodies of these species are of one-layered walls whereas the hyphae growing outside are covered with an additional thin, denser layer on the surface. The latter also surrounds the conidia except their apical protuberance and papilla. On the basis of the yet unpublished results these authors concluded two-layered spore walls to be a general feature in *Entomophthorales*, with differences concerning only the compactness of these layers in particular parts of the spore surface. However, so far there have not been any similar investigations of representatives of non-entomopathogenic genera of entomophthoralean fungi. According to Tucker (1981) unitunicate conidia containing one nucleus have been observed, or may be supposed to occur, in some species of non-entomopathogenic species infecting lower invertebrates. For practical reasons, the present work maintains the division in monokaryotic conidia with distinctly two-layer membrane visible under ordinary light microscope and two to many nuclear conidia with one-layered conidial wall, treating possible double layer structure distinguishable only under electron microscope as a discrete two-layered one (cryptobitunicate). So with regard to the structure of the primary conidia the entomophthoralean species may be divided into oligo- or polykaryotic — containing 2 to several dozen or even over a hundred nuclei and surrounded by the unitunicate (or cryptobitunicate) walls, or monokaryotic with the walls unitunicate or distinctly bitunicate.

Until recently there also seemed to exist a correlation between the conidia of the first type and the unbranched conidiophores as well as that between the formation of the monokaryotic conidia with double wall only on branched conidio-

phores. However, the discovery and description of the genera *Strongwellsea* (Batko & Weiser 1965) and *Eryniopsis* (Humber 1984), as well as the presence of branched conidiophores is some *Conidiobolus* species (King 1976, 1977) have generally proved no such correlation to exist. The peculiar character of the conidiophores and conidia formation of such genera as *Ballocephala*, *Meristacrum* and *Zygnemomyces* further complicate such considerations. There have so far been no data concerning the karyology of the species of *Zygnemomyces*. However Tucker (1981) followed by Ben-Ze'ev and Kenneth (1982) placed them in the family *Ancylistaceae* due to similar onthogenesis and infected hosts, whereas Humber (1989) proposed a new family, *Meristacraceae*, for the forms of peculiar conidiophore structure having, however, ancylistoid nuclei.

As regards shape, the primary conidia may be regularly globose, globose with a convex papilla, obovoid, ellipsoid, pear-shaped, truncate-campaniform, lageniform, clavate, turbinate, cylindrical, conoid and fusiform (Fig. 7). Good and still frequently used Lakon's (1919) classification of the conidia comprises, unfortunately, only entomopathogenic forms. Later attempts at grouping the species according to conidium shapes (Hutchison 1962, Gustafsson 1965, MacLeod & Müller-Kögler 1973, MacLeod et al. 1976) are gradually abandoned owing to the progress of karyological characteristics often indicating some taxonomical inconsistency of groups separated only on the basis of their morphological resemblance. At present only the genus *Entomophthora* Fres. sensu Remaudière et Keller (1980) is characterized by the exclusively bell-shaped, truncate (truncata-campaniformis) primary conidia and the subgenus *Zoophthora* in the genus *Zoophthora* — which has cylindric to oblong ellipsoid primary conidia.

The surface of the primary conidia is usually smooth and adhesive but some species of the genera *Massospora* and *Zygnemomyces* may have rough or delicately echinulate spores.

Almost all representatives of the entomophthoralean fungi show the ability to form secondary conidia. This name is used for the spores produced on tubular or capillary conidiophores — often very short or hardly observable at all — protruding from the primary conidia. At least five different types of such sporulation have so far been described and in particular types some specific forms can be separated. The formation of secondary spores appears in most entomophthoralean species as simple resporulation — if one primary conidium produces one (or sporadically two or three) secondary spores. Some species of *Basidiobolus* and *Conidiobolus* show an ability for so called multiplicative resporulation, when regularly greater numbers of the secondary spores are produced by each primary or maternal one. The most widespread forms of the secondary conidia are the adhesive ballospores formed on relatively thick but usually

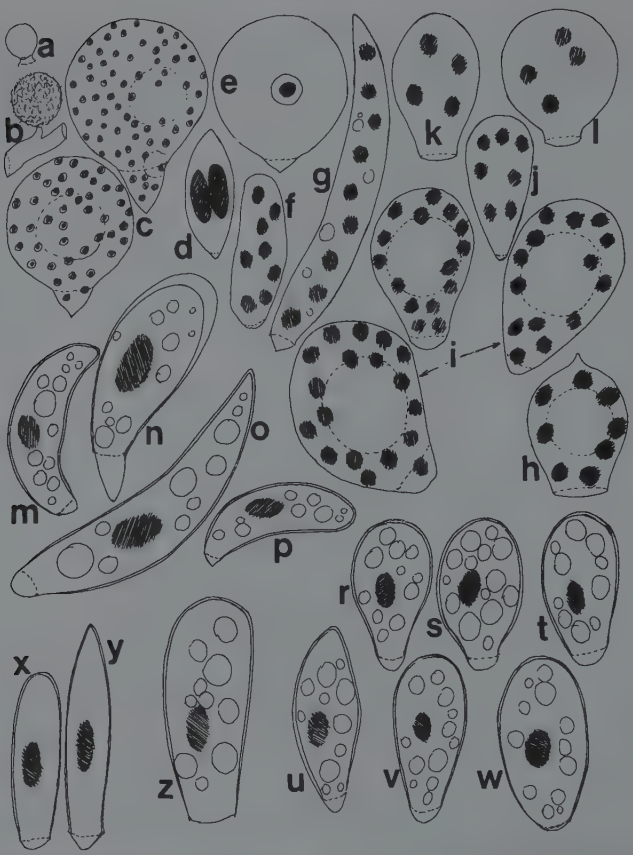


Fig. 7. Different types of primary conidia; a-l — unitunicate: a — spherical, smooth, epapillate with a collarette (*Ballocephala*), b — spherical, echinulate, epapillate, passively detached (*Zygnemomyces*), c — polykaryotic ancylistoid, papillate (*Conidiobolus* sp.), d — dikaryotic entomophthoroid, subpapillate (*Massospora* sp.), e — monokaryotic basidioboloid, subpapillate (*Basidiobolus* sp.), f,g,h — entomophthoroid oligokaryotic: f — elongate, epapillate (*Eryniopsis caroliniana*), g — elongate, papillate (*Eryniopsis longispora*), h — truncate campaniformis or bell-shaped (*Entomophthora* spp.), i — polykaryotic entomophthoroid (*Entomophaga* spp.), j,k,l — oligokaryotic neozygitoid: *j* — *Neozygites turbinata*, k,l — *Neozygites* spp., n-v — bitunicate, monokaryotic entomophthoroid: m — *Zoophthora* subg. *Erynia curvispora*, n — *Z.* subg. *E. aquatica*, o — *Z.* subg. *E. conica*, p — *Z.* subg. *E. variabilis*, r — pyriform (*Z.* subg. *Neopandora aleurodis*), s — ovoid with over-papillar neck (*Z.* subg. *Neopandora* sp.), t,v — ovoid, basally attenuated (*Z.* subg. *Neopandora* spp.), u — subfusiform or obtuse-fusiform (*Z.* subg. *Neopandora dipterigena*), w — ellipsoid (*Z.* subg. *N. heteropteris*), x — oblong cylindric (zoophthoroid) (*Zoophthora* subg. *Zoophthora* spp.), y — oblong conical (Z. subg. *Z. occidentalis*), z — subclavate (*Z.* subg. *Furia virescens*); a,b,f — epapillate (papilla indistinct, not protruding from the conidium outline); c — papilla abruptly protruding from the conidium outline; h,k,l,r,s — basal part constricted into over-papillar neck; t,u,v,w — (subpapillate), papilla merging smoothly from the conidium outline.

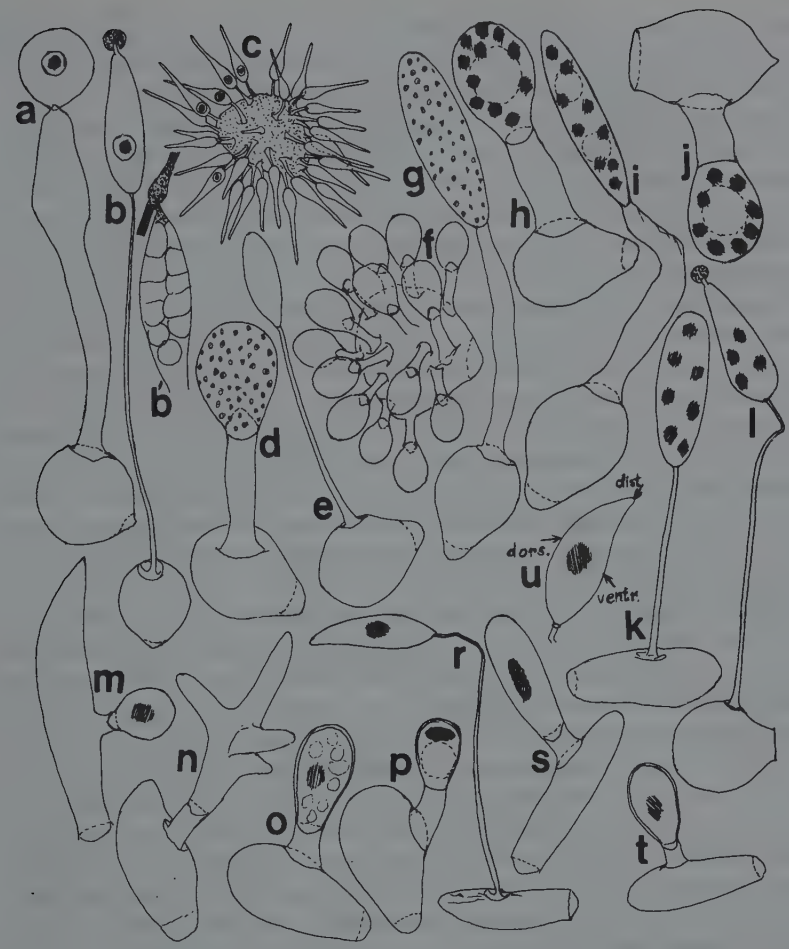


Fig. 8. Secondary conidia of *Entomophthorales*: a-c — *Basidiobolus* spp.: a — secondary ballospore, b — capillispore, b' — capillispore attached to an arthropod seta with the content divided into sporangiospores, c — microconidia (type B) of *B. microsporus*; d-g — *Conidiobolus* spp.: d — secondary ballospore, e — capillispore, f — microconidia (type A), g — secondary elongate conidium; j — *Entomophthora* spp., secondary ballospore; k — capillispore of *Eryniopsis lampyridarum*; l — capillispore of *Neozygites* sp.; m-t — *Zoophthora* spp.: m — pear-shaped secondary conidium of *Z.* subg. *Erynia conica*, n — tetraradiate secondary conidium of *Z.* subg. *Erynia* sp. from moist habitat, o — common secondary ballospore of most *Zoophthora* species of the subgenera *Erynia, Neopandora* and *Furia*, p — "*Entomophthora*-like" secondary ballospores of some *Zoophthora* species of the subgenus *Neopandora*, r — capillispore of *Z.* subg. *Zoophthora* sp. — (in profile): dors. — dorsal outline, ventr. — ventral outline with convex (down) and concav (subapical) sinuosity, dist. — terminal, usually attenuated part, often elongated into more or less distinct beak, s — first series secondary ballospore of *Z.* subg. *Zoophthora* spp., *t* — further series secondary ballospore of *Z.* subg. *Zoophthora* spp (c – after Benjamin, simplified).

short, cylindrical or somewhat widened in the central part conidiophores (Fig. 8a,d,h,j,e). Their shapes are usually similar to those of primary conidia and they maintain the ability to form next series of analogous, but gradually smaller, spores. In the *Zoophthora* species of the subgenus *Zoophthora* the shape of the secondary conidia, especially those of their further (3-5) series, change only by increasing the length to diameter ratio (L:D) and shapes of the spores become less regular (Fig. 8t). Some species of *Zoophthora* subg. *Neopandora* are able to produce secondary ballospores differing from the primary by ampulliform shape, broad and weakly convex papillae often with marked apical point — similarly as in the conidia of *Entomophthora* s. str. — however always monokaryotic (Fig. 8p). In the *Zoophthora* species of the subgenus *Erynia* irrespectively of the conidia similar in the shape to the primary ones, the smaller almost spherical secondary ballospores with relatively narrow, abruptly protruding papilla appear frequently, although often in small numbers. In some species of this subgenus there may be produced in water environment so called „tetraradiate propagules" (Webster et al. 1978) — e.i. the spores with 2-3 lateral outgrowths (Fig. 8n); it seems to be the functional adaptation to hydrochory, comparable with the staurosporic hyphomycetes of water habitats. They seem to be devoid of active ejection structures (Descals & Webster 1984).

Some species of *Conidiobolus* and *Entomophaga* produce non-adhesive secondary conidia of elongated shape and somewhat thickened wall. They are usually born on short and relatively thin, tubular conidiophores normally developed of reduced and practically non-functioning ejection mechanism, showing, however, the presence of small and narrow, rudimentary papillae (Fig. 8i).

The next type of simple resporulation are so called capillispores or capilliconidia, i.e. passively detached, adhesive at the distal end or non-adhesive at all, conidia produced on very thin (capillary — hence the name) but relatively long sporophores, growing from the primary or secondary ballospores (Fig. 8b,e,k,l,r). They occur in some species of *Basidiobolus*, *Conidiobolus* (subg. *Capillidium*), *Meristacrum*. *Neozygites*, *Zoophthora* (subg. *Zoophthora*) and one species of *Eryniopsis*. Their shapes, in particular contours of dorsal and ventral lines in profile (Fig. 8u) can in some cases be treated as features of species differentiation (Keller 1980, Bałazy 1984, 1986). In older references they were often called almond-shaped or amygdaliform secondary conidia, however their particular forms and structures were rather weakly included into systematical considerations. Batko (1974) proposed their following differentiation and naming:

— prohaptospores, the capillispores of thin walls, adhesive on the all surface — occurring in *Eryniopsis lampyridarum* (Thaxter) Humber (Batko 1974);

— haptospores, the capillispores of somewhat thickened, dry walls, with differentiated adhesive structure at the distal end — e.g. in *Basidiobolus* spp. and *Ne-*

ozygites spp. but sporadically also occurring in some species of *Zoophthora*, subg. *Zoophthora*;

— ahaptospores, the capillispores as above with distal end closed by thinner, probably unitunicate, wall, but without specialized adhesive structure (mostly in the species of *Conidiobolus* subg. *Capillidium* and *Zoophthora*, subg. *Zoophthora*).

Detailed comparisons of the capillispore shapes in the species of *Zoophthora* subg. *Zoophthora* (Keller 1980, Ben-Ze'ev & Kenneth 1981 b, Bałazy 1984, 1986) showed their usefulness for species differentiation, applied in this review. Their capillary sporophores are referred to here as thin when their basal thickness does not overstep 1,5 µm and the terminal one is thinner than 1 µm, whereas these of greater respective diameters are determined as „relatively thick". Since the capillispores are mostly produced by subsequent series of the secondary ballospopres rather than by the primary ones, their size is of little importance for the taxonomy, whereas the shape, particularly L:D ratios, ventral contour outline sinuosity (see Fig. 8u) and form of the distal half, seem to be essential. Not infrequently observed have been cases of the secondary capillispores growing out from those „maternal", similar, yet always considerably smaller and often underdeveloped. The capillispores, especially prohaptospores and those with adhesive tips, show obvious adaptation to zoochory analogous with the conidia of some entomopathogenic hyphomycetes (e.g. *Hirsutella* species). In some species of *Basidiobolus*, cases of their growth from the vegetative cells of the hyphae have been reported, and having been freed they may occasionally function as several-spored sporangia (Gäumann 1954). Such capillispores mostly of *Basidiobolus* species attached to the body or setae of some small arthropods were treated by Thaxter (1914) as „peculiar" epizoic hyphomycetes related to *Laboulbeniales* under the generic name *Amphoromorpha* Thaxter (Blackwell & Malloch 1989).

The forms of multiplicative resporulatrion are two types of microconidia and sporangiospores. The microconidia of the type A are relatively small ballospores produced on numerous thin and short, tubular sporophores growing out from the primary conidia. They originate as a result of archetomic division of the maternal spore content and are characteristic for some species of *Conidiobolus*, recently groupped in the separate subgenus *Delacroixia* (Sacc. et Syd.) Tyrrell et MacLeod, 1972 (Ben-Ze'ev & Kenneth 1982). The microconidia of the type *B*, described for only one species, *Basidiobolus microsporus* Benjamin, differ from the former basically in the type of division of the maternal conidium content which is monokaryotic and in effect of a series of monotomous divisions a greater number of small, monokaryotric spores is produced; Humber (1981) proposed for them the term „microspores". Uninunclear, small, thinwalled spores originating inside some cells of the thallus and some conidia of *Basisiobolus* spp. in result of monotomous divisions are considered to be typical spo-

rangiospores (Gäumann 1954; Blackwell & Malloch 1989). They are freed through basal rupture of the cellular wall.

Also known are cases of the ballospores transforming directly into the resting spore stage by the thickening of the wall, usually accompanied by the loss of the papilla. This phenomenon occurs in some species of the genus *Conidiobolus* and resting spores thus formed have been named „loricoconidia" by Batko and Weiser (1965).

It was Drechsler (1951) who expressed a supposition that the conidial sporulation of the genus *Ballocephala* may also be a specific type of simple resporulation. Namely, the spherical or ampulliform sporogenous cells occurring laterally on upper part of the non-septate conidiophore can be considered as the primary conidia devoid of papille. The spores formed on these cells and forcibly discharged would thus in fact be the secondary ballospores. According to this view the only genus not reported to have the secondary conidia would be *Zygnemomyces*.

The resting spores of zoopathogenic species are not able to infect their hosts directly. The infection occurs by means of conidia produced on germ hyphae, called germ conidia. This type of conidia has hitherto been recognized in just a few entomopathogenic species. One may only suppose that they should be of essentially the same character as the primary conidia, yet by no means can they be used for taxonomical purposes. Zygospores of some *Neozygites* species form capilliconidia as infective units (Bitton et al. 1978, Keller 1991).

Though the majority of the entomophthoralean species is connected with highly humid environments, their ability to actively eject their conidia indicates that they are a group of primarily terrestrial organisms. Even the species of the genus *Ancylistes* parasitizing in seaweed cells produce the ballospores and shoot them up in the air only when their hyphae touch water surface. On the other hand there is no evidence of elements caused rejection in the tetraradiate or stellate conidia of *Zoophthora* subg. *Erynia* species formed in water (Webster et al. 1978).

Some entomopathogenic species of *Conidiobolus* (*Ancylistaceae*) and the majority of *Entomophthoraceae* (numerous species of *Entomophthora*, almost all of *Zoophthora* and at least one of *Eryniopsis*) produce a particular kind of hyphal structures called holdfasts or rhizoids, thanks to which the infected host specimen while dying or shortly before, is for the sporulation period affixed to the substrate — usually in the place frequented by other specimens of the same species or in their feeding grounds, in a situation which favours direct sowing of the infective units on potentially susceptible hosts or facilitates the contact of the latter with the secondary conidia (Batko 1974). Such rhizoids are of the form of relatively thick hyphae often widened at their ends into disc-like structures of irregularly fiord-like sinuous margins, devoid of plasmatic content when ripe, simple or branched, often closely tangled into string-like structures called pseudorhizomorphs.

Strong attachment of organic particles or plant piles to the terminal parts of rhizoids as well as frequently observed necrotic spots on leaves under holdfasts suggest the excretion of some, probably viscous, substance by these structures of mycelium. Different types of holdfasts and their aggregations are produced (Fig. 9). Until the seventies of the 20th century these structures used to be ascribed the value of features differentiating genera (Nowakowski 1883, Lakon 1919, Batko 1964 b,c,d), lately disproved (Ben-Ze'ev & Kenneth 1982). However, these features can be of essential use on lower systematic levels (subgenera, species). These structures are an unquestionable proof of a high degree of adaptation to parasitism in large invertebrates able to migrate and they seem to be linked with a certain stage in the phylogenesis of the entomophthoralean fungi (Bałazy 1984).

In the entomophthoraceous species with digitately branched conidiophores and monokaryotic conidia (the genus *Zoophthora*) there occur as a rule — though sometimes hard to distinguish — the sterile hyphae called pseudocystidia, appearing on the surface of host's cadaver before the development of conidiophores. They are unbranched, only exceptionally with irregularly wart-like or shortly tubular outgrowths at ends, oligokaryotic during the growth phase, usually conically narrowing towards the tips which are obtuse or sometimes slightly swollen. They usually stick out distinctly over a layer of the conidiogenous cells (pseudohymenium) in the beginning phase of the conidiation (Fig. 10), but shortly after they loose their content and often collapse. They are thought to function as structures perforating primarily the host cuticle to facilitate the growth of the conidiophores from the hemocele (Brobyn & Wilding 1977). Their morphology is of some importance in the differentiation of subgenera into the genus *Zoophthora*.

The ontogenesis of the entomophthoralean fungi has been thoroughly investigated for only a few species with most studies devoted to entomopathogenic strains. Its most general outline looks as follows. In favourable environment conditions, the resting spore germinates producing one or a few germ tubes on which germ conidia are formed. They are able to infect appropriate hosts. If such conidium falls on an unsuitable substrate it produces secondary conidium also endowed with the ability to infect the hosts and in most cases to resporulate. When encountering a body surface of a susceptible host the germ tube excretes enzymes which cause local dissolution of the cuticle making possible the penetration of the hypha into the hemocele. The mycelium growing into host's body cavity subjects usually fragmentation into the hyphal bodies and protoplasts, which multiplicate and penetrating into all organs dissolve them by means of mostly proteolytic and lipolytic exoenzymes. The injuries of the inner organs and accumulation of fungal metabolites result in the death of the host. This, however, does not inhibit the growth of the mycelium: filled with it the host body becomes mummified and the

Fig. 9. Terminal modifications of rhizoids in *Entomophthorales*: a -slightly widened with organic particles of substrate (*Zoophthora* subg. *Erynia conica*), b — disc-like expansion of hyphae united into a pseudorhizomorph (*Zoophthora* subg. *Zoophthora miridis*), c — typical disc-like, reticulate expansions (*Zoophthora* subg. *Neopandora vomitoriae*), d — a series of expansions along the hypha on uneven substrate (*Z.* subg. *N. vomitoriae*), e — an aggregation of irregular branches (peripheral rhizoids of numerous species of *Z.* subg. *Neopandora*, this case — *Z. dipterigena*).

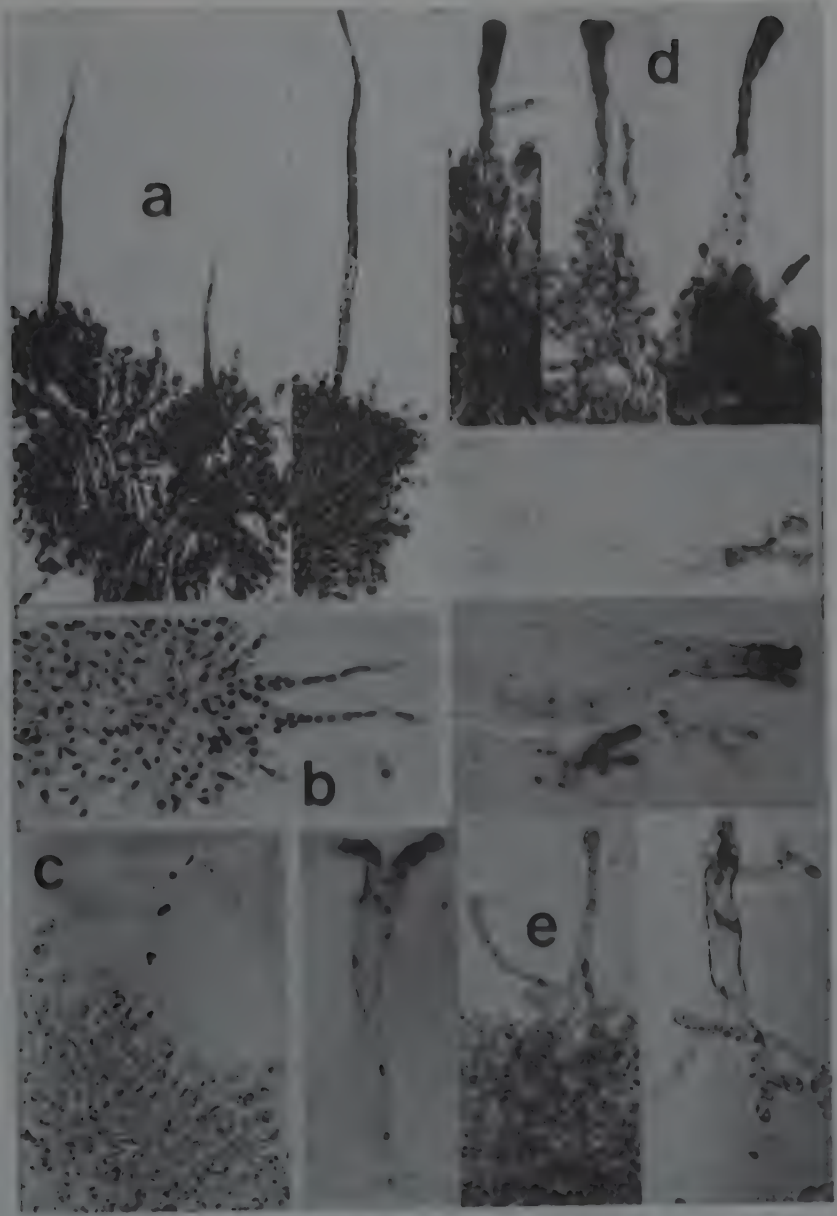


Fig. 10. Pseudocystidia of different species of *Zoophthora*. a — Z. subg. *Neopandora lipae*. b — Z. subg. *Neozygites echinospora*. c — Z. subg. *Erynia aquatica*. d — Z. subg. *Erynia ovispora*. e — Z. subg. *Erynia sepulchralis*.

conidiophores — preceeded in some forms by rhizoids and pseudocystidia — begin to grow out from its inside. Subsequently produced conidia may very likely infect further host specimens which not infrequently leads to strong epizootics.

In the stage of vegetative development, most probably after host's death, the hyphal bodies or hyphae are able to conjugate in pairs forming the zygospores or transform into azygospores without conjugation. It is highly probable that the resting spores of most entomophthoralean fungi keep vital for several years. Factors responsible for their germination have not yet been precisely determined.

The development of saprophytic species is basically analogous with the exception, of course, of the infection phase and the mummification phenomenon and with the addition of the competitive factors involving other saprophytic microorganisms of nutritional substrates. It is the prevalent opinion that the saprophytic *Entomophthorales* can live in different habitats thanks to rich sets of excreted enzymes which enable them to make use of organic matters unassimilable by other microorganisms.

Trophic relations

With regard to trophicity the entomophthoralean fungi can be divided into several definitely distinct groups relatively weakly connected with particular systematic units over the species level, apart from the majority of genera of the family *Entomophthoraceae.* As has already been mentioned they are mostly specialized parasites of arthropods — most frequently insects, mites and harvest spiders. The arthropod pathogens are mostly groupped in the family of *Entomophthoraceae,* however, at least about ten species of *Conidiobolus* (*Ancylistaceae*) and one of *Meristracrum* (*Meristacraceae*) are of the same character. Moreover, a considerable number of species of the genus *Conidiobolus* show distinct, although facultatively manifested or occasionally stated, pathogenic capabilities in relation to arthropods (Ben-Ze'ev & Kenneth 1982, Bałazy et al. 1987). Weak pathogenicity for insects was also stated in some species of *Basidiobolus* (*Basidiobolaceae*) by Krejzova (1973), Coremans-Pelseneer (1974) and others. Two species of the genus *Macrobiotophthora,* counted first into the family *Entomophthoraceae,* parasitize in tardigrades and nematodes like the majority of species of the genera *Ballocephala, Meristacrum* and *Zygnemomyces* of the family *Meristacraceae* — so recently they were arranged among the representatives of the latter (Humber 1989). It is not, at present, known whether zoophagous but non-entomopathogenic forms are in fact represented in such a small number in the here discussed fungus order or whether their scarcity is due to the lack of more thorough studies in the pathology of micro- and mezofauna. The species of the genus *Basidiobolus* — composing simultaneonsly the family *Basidiobolaceae* —

are generally considered to be saprophytes occurring in soil and decaying organic matter and in excrements of amphibians and reptiles, but they can occasionally — similarly as some species of *Conidiobolus* — cause disease in the tissues or organs of warm-blooded animals and man (Emmons & Bridges 1961, Gilbert et al. 1970, Coremans-Pelseneer 1976, King & Jong 1976).

The least numerous are plant pathogens. Beside several probably facultatively mycophilic species of the genus *Conidiobolus* other known phytopathogenic species are *Completoria complens* Lohde (1874), as a parasite — probably obligatory — in the cells of fern gametophytes, and three species of *Ancylistes* developing in desmid algae (*Desmidiaceae*).

Until recently most entomopathogenic *Entomophthorales* were considered to be obligatory parasites. Advanced works on the in vitro culturing of these fungi show the complexity of the situation: there remain indeed some species or groups (*Massospora*, *Neozygites*) which have not so far been cultured on any artificial medium despite different endeavours. The species of the genera *Entomophthora* Fres. sensu Remaudière et Hennebert and *Strongwellsea* seem to be very close to them in this respect. A great majority, however, grow on artificially prepared substrates properly selected and sufficiently rich in proteins, lipids and vitamins. Nevertheless, many strains show in such cultures disturbances in the development, abnormalities in the morphology, frequent lack of sporulation or its loss after several passages through artificial media and at least progressive degeneration and dieback of the mycelium. This seems to indicate the absence of a stronger propensity for a saprophytic mode of life. It thus seems proper to refer to these pathogens as obligatorily or non-obligatorily biotropic rather than obligatory or facultative parasites.

There is at present no uniform approach among mycologists towards the matter of host selection by particular strains considered to be the same species. Some insect pathologists (S. Keller, R. Humber, R. Soper) segregated so called pathotypes inside particular species, mostly on the basis of pathogenesis and development of a given pathogen. In recent papers, however, Humber (1986, 1989) presented an opinion which seems to question a species identity of strains hardly differing in their morphology and development and infecting even closely related host species. It agrees, as a rule, with Bałazy's (1986) view as concerns a relatively large group of strains counted into the genus *Zoophthora* subg. *Zoophthora*. Similar opinions appeared earlier mostly in effect of some exact studies on the morphology, pathogenicity and epizootics in relation to particular species like „*Entomophthora calopteni*", „*E. egressa*", „*E. exitialis*" and others, included into the synonymy of other, usually widely spread species.

On the other hand Dr. E. Voronina (pers. comm.) basing on her investigations on *Conidiobolus obscurus* (=*Entomophthora thaxteriana*) impugns the pertinence of the differentiation on separate taxa — in the true taxonomical sense — of strains

closely related after morphology, even if the pathogens originate from remote host arthropods. In her opinion precincts of potential hosts for particular pathogenic species are very wide and only natural or artificial selection (e.g. in cases of epizootics during pest gradations or in laboratory biotests) allows to separate series of strains of especially high capabilities to infect a given species or group of hosts. Moreover, she stated that strains showing features close to obligatorily biotropic pathogens are dominating during the culminative phases of epizootics whereas enzootic level of host's mortality is caused mostly by strains of moderate or even weak pathogenic abilities.

As a matter of fact both real host ranges for particular strains and a scale of the possibility of their physiological adaptation to non-typical hosts or artificial substrates are too poorly and fragmentarily recognized to justify any valid generalization at present. So it seems to be better not to draw any principal conclusions.

We know at present that the pathogenic *Entomophthorales* show different degrees of parasitic specialization. Phytopathogenic species of the genera *Ancylistes* and *Completoria* seem to be obligatorily biotropic and closely connected with their convenient hosts. All hitherto recorded species of the genus *Ballocephala* and *Macrobiotophthora vimariensis* are parasites of tardigrades while two known species of the genus *Zygnemomyces*, *Meristacrum asterospermum* and *Macrobiotophthora vermicola* develop in nematodes. A majority of these species has only been observed in vivo in their hosts during invertebrate rearing or investigated post mortem in fixed microscopical preparations and may therefore be treated as biotrophic forms, at least until their possible development on artificial media is stated.

The species of the genus *Conidiobolus* were considered mainly saprophytic or occasionally zoopathogenic (Drechsler 1953, 1961, 1965, Srinivasan & Thirumalachar 1962, King 1976, 1977); lately a number of typically entomopathogenic strains excluded from the genus *Entomophthora* sensu latissimo have been transferred into this genus (Remaudière & Hennebert 1980; Humber 1981, Ben-Ze'ev & Kenneth 1982), or originally described under this generic name (Bałazy et al. 1987). The entomopathogenic species of the genus *Conidiobolus* show different degrees of pathogenicity in relation to their hosts and seem to reflect in this a general ability of the order. Some strains of the common, normally saprophytic species *C. coronatus* may be non-specialized optional (facultative) pathogens of some arthropods as well as other animals, icluding warm-blooded vertebrates (Domsch et al. 1980). Another group comprises poorly specialized and relatively weak insect — and probably other invertebrate — pathogens, e.g. *C. osmodes* Drechsler mostly in larvae of alfalfa weevil, *Phytonomus* spp., *C. obscurus* (Hall et Dunn) Remaudière et Hennebert in aphids. Other typical insect pa-

thogens are also known; they are either distinctly specialized to a narrow host range (*C. pseudococci*, *C. destruens, C. gustafssoni*) or of wider host range-like *C. thromboides*. In view of the recently published observations on the presence of the resting spores resembling those of the entomophthorales in numerous dead specimens of small arthropods inhabiting forest litter, subcortical sawdust and other places of dead organic matter accumulation (Bałazy & Wiśniewski 1982; Bałazy et al. 1987), a general view on the common saprophytism of numerous *Conidiobolus* species in these habitats may seem debatable and further studies in these problems should be undetaken. A. Callaghan (pers. comm.) is of the some opinion.

The hirtherto known species forming the family of *Entomophthoeaceae*, except the above mentioned *Completoria complens* Lohde and both species of *Macrobiotophthora*, are pathogens of arthropods specialized by the ability to infect of their host species only in determined development phase, as well as by other physiological, behavioral and phenological adaptations in the disease process, which aim often to epizootics (Batko 1974, Soper 1974, 1981, Humber 1976, 1986).

A real host range for most genera and species is difficult to assess because only single biotests have so far been carried out. In view of rather great resemblance of allied species as regards their morphology and variability — the correctness of investigated strain identification is often doubtful. It particularly concerns species of the genera *Entomophaga* — mainly those infecting grasshoppers, caterpillars and tenthredinid larvae, *Entomophthora* from adult diptera and *Zoophthora* strains showing features of the subgenera *Neopandora* and *Zoophthora* in the sense of Ben-Ze'ev and Kenneth (1982). Entomophthoralean strains of very similar morphology may distinctly differ in the host selectivity, pathogenesis, physiology and in biochemical properties. A wider recognition of these problems allows to suppose that host ranges for particular species are rather very narrow, most probably conditioned mainly by resemblances of host's biology and physiology, which in numerous cases may be convergent with their affinity in the systematical arrangement. However, despite a considerable progress in the knowledge of the entomophthorales in the last two decades, information concerning their physiology and biochemistry is still scarce and fragmentary or, in relation to some species, even controversial.

Phylogeny

There are no data on the phylogenic age of the entomophthoralean fungi. On the basis of indirect premises one can only suppose that specialized arthropod pathogens, predominating in the species composition of the group, separated rela-

tively lately, as indicated by the fact of the greatest differentiation of forms affecting phylogenetically the youngest arthropod groups (B a t k o 1974), i.e. *Diptera, Hemiptera, Lepidoptera* and *Coleoptera* from among insects and *Acarina* and *Opiliones* from araneids. The present opinion is that the entomophthorales trace their origin back to saprophytic and facultatively zoo-or phytopathogenic terrestrial forms of the lower fungi showing features generally close to contemporary genus *Conidiobolus* (H u m b e r 1984c, E v a n s 1 9 8 8). In considering the morphology and ecology of representatives of this genus one can indeed observe that the adaptations to the parasitism in arthropods augment in its representatives by means similar as in particular taxa of the family *Entomophthoraceae*. Relatively numerous cases of the occurrence of forms showing intermediate features as well as frequent lack of sharp borderlines between species of similar morphology but distinctly different host range seem to confirm B a t k o' s (1974) supposition on the contemporary intensive speciation processes in the group of entomophthoralean arthropod pathogens. The break of potential host's resistance barriers accomplished by means of physiological adaptations must not necessarily be accompanied with rough morphological differentiation. The comparative studies in biochemistry of strain series of different origin may answer this question. On the other hand, some non-entomopathogenic forms developing in lower invertebrates seem to be more primitive (T u c k e r 1981) and it is debatable to consider this fact as only a developmental retardation.

Systematics

In the beginning period of the investigations on *Entomophthorales* B r e f e l d (1877, 1884) classified them into the class of *Basidiomycetes*, as a group close to *Ustilaginales*. In the morphology and development of the species known up to the present there appear indeed elements suggesting their close similarity to the basidiomycete mycelium, e.g. a degree of resemblance of the conidiogenus cells to monosporic basidia, their hymenium-like arrangement usually observed on insects, the presence of pseudocystidia in some genera, appearance of the resting spores superficially similar to teliospores, the biotrophic mode of life typical for the majority of recognized forms. However, basing on the structure of mycelium, character of the sexual reproduction process and features of the propagative spores N o w a k o w s k i (1877, 1881, 1883) correctly classified these fungi as a family *Entomophthoraceae* (in original paper „Entomophthoreen") in the group *Zygomycetes*. Both these taxa were recently elevated to the order (*Entomophthorales*) and class *Zygomycetes* (*Zygomycotina*) ranks respectively (A l e x o p o u l o s 1966, v. A r x 1974, B a t k o 1974 a) and this wiev was generally accepted. W a t e r h o u s e (1973) attributed the family name to Warming, who, however,

only corrected orthography adapting it to the rules of family naming. Both Thaxter (1888) and Lakon (1919) used Nowakowski's spelling.

Although in the past the families *Basidiobolaceae* and *Entomophthoraceae* had often been put into the order of *Mucorales,* the present opinion is that both these families should be included into a well-distinguishable order — *Entomophthorales.* Logically following the idea that the forcibly discharged conidia of the entomophthorales are modified sporangia (aposporic sporangia or monosporic sporangiolae according to Batko and most of earlier author opinions) Kreisel (1969) also included the family *Pilobolaceae* into the order under discussion; this opinion has not, however, been accepted. Despite some reservations that the conidia of the *Zoophthora* and *Strongwellsea* representatives are homologous to monosporic sporangiolae and that the differences of conidial walls may not be essential, the necessity suggested by Batko (1974) to separate groups of species of unitunicate, polykaryotic conidia and to raise them to the family rank was in a modified version confirmed by Tucker and the above quoted authors. They accepted, as a rule, the division of the order into three families according to the proposition of Ubrizsy and Vörös (1966) including Batko's and their own later considerations, supplements and modifications based on the progress of studies in karyology. Developing application of the karyological criteria Ben-Ze'ev et al. (1986, 1987) proposed to distinguish an additional family, *Neozygitaceae.* From among the disinguished families *Basidiobolaceae* include only one genus whereas *Entomopthoraceae* comprises the greatest number of most consistent taxa with respect both to similarities of ontogenesis and thallus morphology. The separate character of *Ancylistaceae* results only from karyological criteria and some intermediary forms may be expected to show in the future. On the basis of so far accessible data such forms seem to be groupped in the genus *Conidiobolus* subg. *Conidiobolus* — mostly these producing rhizoids (e.g. Keller's species *Conidiobolus cercopidis*, *C. pseudoapiculatus*) — and in the genus *Batkoa*, close to *B. apiculata.* The proposition to separate from its range a group of species producing conidiogenous apparatus unlike that of *Ancylistes*- or *Conidiobolus*-type and to include them into a new family *Meristacraceae* Humber (1989) seems to be reasonable. Besides structural differences of conidiophores the majority of these forms show tendencies to affect rather lower invertebrate animals than arthropods. On the other hand the proposal to separate a monotypic family of *Completoriaceae* Humber (1989: 453-454) does not seem to be necessary and sufficiently documented.

The taxonomic criteria in the ranks of genus, subgenus and species were established by Remaudière and Hennebert (1980), Remaudière and Keller (1980), Humber (1981a, 1981b), Tucker (1981) and Ben-Ze'ev and Kenneth (1982). However, in the lower systematic ranks, particularly on the subgeneric and species level, they are sometimes inexact and less consistent, mostly due to lack of full data concerning morphology and ontogeny of

particular species or strains. Any intraspecific taxonomy has not yet been elaborated. The varieties, forms or „races" separated sporadically in the past (Thaxter 1888; 164, Petch 1944: 87, Turian 1957: 91-98) were later elevated to the species rank. The above problem of the pathotypes and strain differentiation based on peculiarities in their physiology, regardless of morphological similarity, usually led to a discovery of some complex character of earlier recognized taxa and to separation of new species (Keller 1980, 1984, 1987, Milner et al. 1983, Soper et al. 1988) or to validation of earlier considered synonyms (Ben-Ze'ev & Kenneth 1981 b, Humber & Ramoska 1986, Ben-Ze'ev 1986 b). The basis for such a separation are either discovery of new structural elements in strain morphology as result of type material reexamination or repeatable particularities in the development and chemical compound production in vitro, mostly izozyme patterns for series of strains revealed by electrophoresis (Milner et al. 1983, Humber 1984, Soper et al, 1988). Parallel biotests to determine a given strain pathogenicity in relation to different arthropod species should be especially helpful in the interpretation of results for taxonomical needs (Papierok et al. 1984, Bałazy 1984, Bałazy et al. 1986). As biochemical charcteristics, natural and experimental host ranges and serological reactions have so far been recognized only for very limited number of strains, they cannot be widely included into this reviev as general guidelines.

The place of numerous species in the systematic arrangement of the entomophthorales is uncertain and needs to be revised and validated due to imprecise descriptions and lack or poor state of evidence material. Thus the present arrangement has a temporal character based on the existing recognition of the group and its representatives.

Occurrence and significance

The entomophthoralean fungi are spread all over the globe in terrestrial habitats except representatives of the genus *Ancylistes* occuring in waters. The majority of species, however, both saprophytic and parasitic of the family *Ancylistaceae*, and from among *Entomophthoraceae* most representatives of the genera *Zoophthora* (mainly the subgenus *Erynia*), *Eryniopsis* and *Completoria*, are connected with damp and moist habitats, as for instance marshes, banks of shady streams, rivers, lakes and pools, damp forests and bushes, caves, cellars and so on. Also in many-storied communities of forest plants more abundant and quantitatively richer entomophthoralean flora occurs in the forest floor vegetation and in intermediate undergrowth layers than in crowns of dominating trees (Fig.11). A considerable number of species shows moderate requirements as concerns the temperature and humidity, occurring however mostly in weakly insolated and aerated habitats.

From among the best recognized one can count here mostly arthropod pathogens *Conidiobolus obscurus*, *Entomophthora planchoniana*, most of *Zoophthora* species of the subgenera *Neopandora* and *Zoophthora*, some of *Entomophaga* and a number of *Conidiobolus* species considered to be saprophytic. At least a dozen or so species seem to prefer some dry or strongly insolated habitats in open areas, sandy coniferous forests or crown storey zones of forest trees, although some of them show some tolerance and may also be met inside moderately shady plant associations. According to actual recognition, the following species could be counted among them: *Conidiobolus gustafssoni, Entomophaga aulice, E. grylli, E. tenthredinis, Zoophthora myrmecophaga, Z. anglica, Z. phytonomi, Neozygites fresenii, Tarichium calliphorae* and the common house fly pathogen *Entomophthora muscae* as well as closely related strains affecting syrphid adults — *E. syrphi.*

With regard to the phytogeography, the entomophthorales, except representatives of the genus *Massospora*, are distributed rather homogenously in different climatic zones, contrary to entomopathogenic higher fungi (*Ascomycotina* and *Deuteromycotina*) which are both qualitalively richer and quantitatively much more abundant in tropical and subtropical regions. This is the most essential reason for which the Polish entomophthoralean mycoflora has been elaborated in this review including species not yet reported from Poland, since — in the author's opinion — they may be expected to be found in Poland. Unfortunately deserts as well as subpolar and highest mountain regions have not so far been explored in this respect, excluding some scarce reports concerning resting spore forms (Thor 1930, Bałazy & Wiśniewski 1984). The state of knowledge of the entomophthoralean fungi in different countries and geographical regions is certainly uneven. The saprophytic species and non-entomopathogenic parasites are particulary poorly known, whereas entomopathogenic forms have been studied in more detail usually in connection with epizootics caused in populations of medically important insects and serious arthropod pests in agriculture and forestry. Hence the knowledge of host ranges for particular pathogenic species and relations between systematical units of invertebrate animals and their entomophthoralean pathogens are not objective, since they depend on the degree of human interest and methodical and technical difficulties of investigations. Relatively well recognized are pathogens infecting adult stages of flies (*Diptera*) and different generations of homopterous bugs (*Homoptera*), mostly aphids and cicads. Less numerous but of great importance are pathogens of caterpillars and few species affecting adult moths (*Lepidoptera*), about 15 species infecting larvae and imaginal individuals of beetles (*Coleoptera*) and heteropterous bugs (*Heteroptera*), whereas from hymenopterans (*Hymenoptera*), grasshoppers (*Orthoptera*), earwigs (*Dermaptera*), cocroaches (*Blattodea*) and neuropterans (*Neuroptera* including *Raphidioptera*) only one or two-three species are known for each group. The entomophthoroses of araneids were considered as unusual phenomena (Lagerheim 1898, Petch

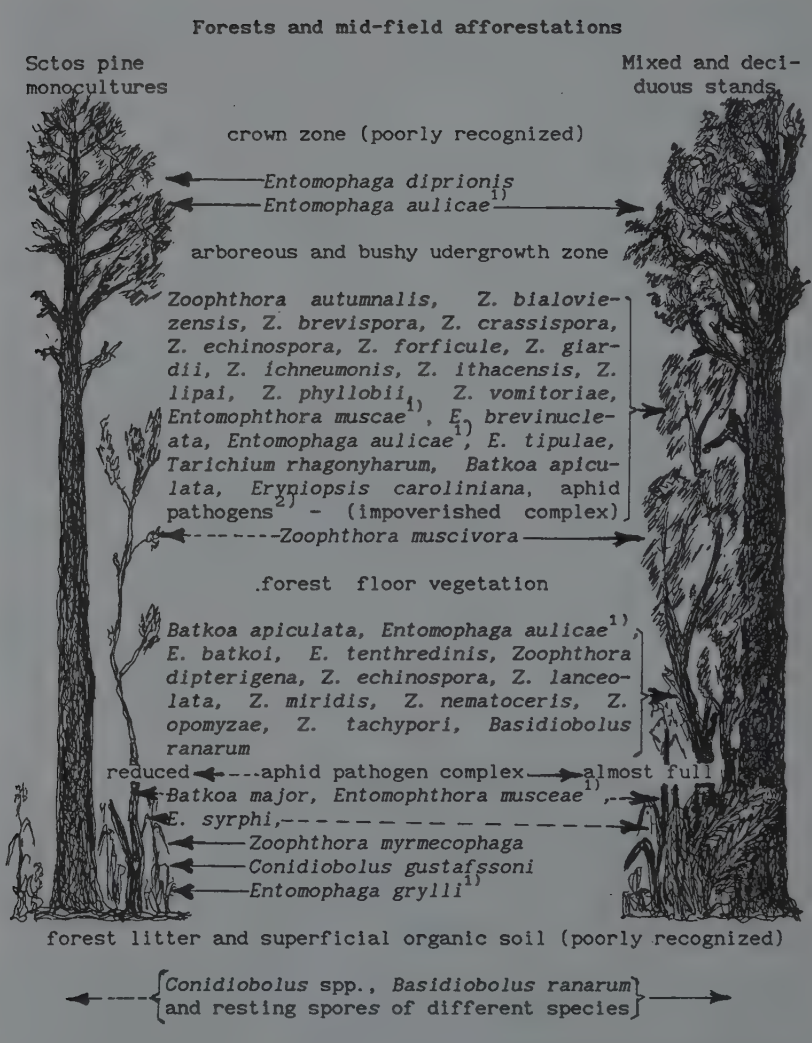


Fig. 11. Occurrence of common entomophthoralean fungi in different habitats (after author's observations in Poland).
1) — representatives of complex species
2) — about 10 species occurring commonly in aphid populations (Zimmermann 1978, Bałazy et al. 1990).

Agroecosystems
(except aphid pathogens poorly recognized)

1-year cultures (cereals, row crops, gardens)	perennial crops	balks and xerothermic swards
above ground		
Zoophthora anglica	*Zoophthora phytonomi*	*Entomophga aulicae*[1]
Zoophthora opomyzae	*Zoophthora philonthi*	*Entomophthora syrphi*
Zoophthora miridis	*Zoophthora petchii*	*Zoophthora petchii*
Zoophthora radicans	*Conidiobolus osmodes*	*Tarichium* sp.
	Entomophthora muscae[1]	
← *Entomophaga tenthredinis* →		
← *Batkoa apiculata* →		
← aphid pathogen complex[2] →		
← *Neozygites floridana* →		
← *Conidiobolus osmodes* →		

mowed meadows and pastures	not utilized reeded grasslands
Entomophaga grylli[1]	*Zoophthora dipterigena*
Zoophthora phillonthi	*Zoophthora ovispora*
Entomophthora syrphi	*Tarichium* spp.
Zoophthora spp.	*Batkoa apiculata*
Entomophthora muscae[1]	*Entomophthora muscae*[1]
← strongly impoverished aphid pathogen complex →	
← *Basidiobolus ranarum* →	

in soil

A number of *Conidiobolus* and *Tarichium* species and *Zoophthora nouryi* on *Pemphigus* species infesting roots.

Aquatic ecosystems
(riparian ecotone species)

Basidiobolus ranarum, Entomophaga kansana, Entomophthora culicis, Eryniopsis longispora, Zoophthora aquatica, Z. curvispora, Z. conica, Z. nematoceris. Z. ovispora, Z. sepulchralis, Z. variabilis, Tarichium spp.

Fig. 11. (*continued*)

1940, 1944) but in the last decades a series of both conidial and related resting spore forms were described mostly from mites (*Acarina*). Thus they do not seem to be very rare, but only scarcely investigated. Despite large studies on true spiders (*Arachnida*) no entomophthoroses have been discovered in them yet. The review of references concerning entomophthoralean fungi on harvest spiders (*Opiliones*) and mites was included in the related papers of Bałazy (1978), Bałazy and Wiśniewski (1984) and Bałazy et al. (1987).

The distribution of non-entomopathogenic entomophthorales is very poorly known; particular species have so far been reported usually from single stations, so such data are unsuitable for a wider discussion. The saprophytic species are probably distributed everywhere, but more comprehensive elaborations were made only in Southern Asia and North America. Almost complete references were listed by King (1976a, b, 1977) and Tucker (1981).

The role of the entomophthoralean fungi in nature is very important. As specialized animal parasites of great infective potential with simultaneous distinct selectivity as regards hosts, most of them are important agents in controlling population density of particular invertebrates. Thus, they are a homeostatic factor in ecosystems. Owing to short ontogeny cycles, different kinds of propagative resporulation, a considetrable tolerance as concerns climatic conditions and usually distinct correlation with host's development — their activity used to appear as erruptive epizootics, often leading to the extreme disappearance of a given animal population. This ability noticed soon after the discovery of this fungus group caused increasing interest in these pathogens as a potential pest insect control agent and led to a somewhat incorrect opinion as if these fungi were allegedly useful for man („The enemies of our enemies" — Batko 1974: 210). At present investigations aiming to use these fungi in agricultural practice against some noxious insects and mites are carried out on a considerable scale in several research programs.

The entomophthorales are also very important and interesting from scientific point of view. Their particular plasticity, differentiation in morphology and degree of functional organization of the thallus, karyology, biochemistry, physiology and trophic relations present an attractive field for studies in the phylogeny of the lower fungi as well as their taxonomy and pathogenesis. In the current situation of strong anthropogenic pressure on the environment and icreasing pollution some of these species, especially those susceptible to strange influences, may be good bioindicators of changes in the biosphere.

Collection, preparation, culturing and storage

At the beginning it was the prevalent opinion that these fungi are exclusively insect pathogens, thus they were expected to be found only in host's populations.

Thaxter (1888) recommended to look for them mostly in wet and shady forest habitats, in particular along streams, lakes, rivers and their banks. From such habitats also originated most collections reported earlier by Nowakowski (1877, 1881, 1883). The discovery of saprophytic and phytopathogenic forms has considerably widened the range of information on their possible habitats. According to further studies on non-entomopathogenic species the entomophthorales may be expected in all terrestrial habitats and sites (Srinivasan & Thirumalachar 1967, King 1976, 1977, Tucker 1981), since some representatives are or seem to be especially connected with waters or moist areas. It concerns first of all forms affecting lower invertebrates (*Nematoda, Tardigrada*) living in swampy sites. However, these fungi have usually been observed either in laboratory rearings of these animals or in fixed material in microscopic preparations. As in the past, also further reports of these pathogens may be expected mostly from accidental collections and cultures in vivo. However, last decades brought considerable progress in preparing suitable artificial media for different groups of animal pathogens, so that some perspectives of culturing them in vitro cannot be excluded. The species infecting small arthropods occur in their population under suitable environment conditions and are especially frequent in different damp decayed substrates, mostly in mites. Because of very short time of their vegetative development which determines the duration of parasitic phase they are most frequently observed in the form of resting spores inside their host exoskeleton, if the latter is sufficiently persistent. The only possible way to obtain such specimens is the microscopical examination of cadavers from sifted material (Bałazy & Wiśniewski 1984, Bałazy et al. 1987). Among the mites shooed away by use of Tullgren or Berlese methods single specimens infected with fungi were only accidentally met. Insect pathogenic species and those occurring in harvest spiders are especially spectacular and their recognition is in most cases very easy, requiring only some attention and care during a search. The infected hosts are usually attached to underside of leaves, to stems or branches and flowers of plants and — in aquatic habitats usually just over water surface — to plants, decayed branches, trunks and logs or stones, usually partially submerged, not infrequently simply on wet soil surface. At the time of epizootics a number of live insects should be collected, too, since it is possible to find in them mycotic structures of an initial development phase.

Materials collected in the area should be kept in sterile glass or plastic tubes and, as a rule, one individual should be placed into one tube, together with a bit of substrate on which this infected specimen was found. While having homogenous and abundant material preliminarily recognized, one can exceptionally treat a greater number of infected hosts as one sample; this can only be done in cases of epizootics. Because of the quick development of pathogenic entomophthoralean fungi and relatively short time of conidial sporulation, collected specimens should

be elaborated immediately. To obtain full characteristics of such species infected host individuals should be placed in damp chambers on microscopic subject or cover glasses — depending on host's size — and continuously observed till good conidial sporulation appears on its surface and/or the resting spores develop inside. In many cases host individuals still alive, may be affixed to different substrates by rhizoids in the phase of agony. Such specimens should be collected and then put into moist chambers for obtaining sporulations and cultures. It is very important to observe an initial phase of the conidiation in order to be able to characterize the conidiophores and types of their possible branching, as well as to obtain a pure population of the primary conidia — the data neseasary for the correct fungus description and species identification (e.g. species *Entomophthora* from adult flies may be correctly identified only on the basis of the primary conidium karyology). The secondary conidia may be easily obtained after longer period in usual moist chamber or by replacing glasses with primary conidia to other chambers, terraria or weakly aerated rearing containers. For arthropods of very small size (mites, thysanopterans, young stages of aphid, small flies) damp chambers of small capacity, for instance those made in styropiane or plastic mass microchambers (Bałazy & Wiśniewski 1986) are recommended. The conidia thrown out onto the sterile cover slides in damp chambers may serve to inoculate media (Keller 1987). Another way is to canopy specimens with sporulating mycelium over the surface of medium in Petri dishes or in flasks. Infected host specimens, especially those bigger and well mummified but showing no external growth of mycelium, can be subjected to surface sterilization (desinfection) before placing them in moist chambers or in dishes containing media. For this purpose a specimen should be submerged for 20-30 seconds in 2,5% water solution of sodium hypochloride and subsequently rinsed 3 times a minute in sterile water. Such sodium hypochloride solution can also be applied for rinsing resting spores taken out from cadavers before inoculation of media. Alternatively 1‰ solution of the mercuric chloride may be applied but the desinfection time should be shorter — 5-15 seconds — depending on an arthropod size. For very small and delicate hosts these methods may be risky, so such individuals may only be rinsed several times in sterile water and subsequently carefully dried in sterilized lignin or filter paper.

The isolation of pathogenic entomophthorales to pure cultures is relatively difficult because of the necessity to apply special works preventing contamination with other microorganisms and peculiar media containing convenient nutritive compounds. Several dozen of different nutritive substrates were in the past used for culturing pathogenic entomophthoralean fungi (Brefeld 1884, Speare 1912, Sawyer 1931, Schweizer 1947). By the end of 1950 Müller-Kögler (1959) presented a new method of culturing these fungi on coagulated egg yolk which has been widely applied in different modifications, especially for

initial isolation of strains and for some physiological studies. The author most frequently applies the following compositions:

1- Sabauraud-dextrose-agar enriched with 10 egg yolks per 1000 ml (SDEYA);
2- peptonized broth-agar (Bacto-pepton or similar) enriched with egg yolks in the same proportion (BPEYA);
3- the above medium with addition of 5 g yeast extract per 100 ml (BPYEYA).

In cases of poor growth other substances like vitamins, fatty acids, powdered milk, meat or potato extract may be added (Keller 1987, Urbańczyk et al. 1992). In American laboratories good results were obtained by adding some soya been products (Latgé et al. 1977, Humber & Soper — pers. comm.). A medium for the persistent cultivation should be carefully selected depending on requirements of particular strains. However, these requirements have been known only for few species. For the initial isolation of strains from infected hosts it is ueful to add antibiotics to an applied medium independently of the previous surface host sterilisation. This is necessary when we expect to obtain cultures from the hyphal bodies or resting spores taken out from host's body cavity. The same procedure should be used checking resting spore germination if they do not originate from pure cultures.

The isolation of saprophytic species do not require usually any particular medium composition, however — because of microbiologically rich habitats of their occurrence — cases of different contaminations are rather frequent. To prevent them special technics of initial inoculum placement have been recommended; among them most popular is to hang up small portions of investigated material on damp filter paper in the underside of Petri dish lid over a medium (Drechsler 1953, King 1976 a, Smith & Callaghan 1987). Any necessity to enrich common media like potato-dextrose agar (PDA), Sabouraud-agars (SA), malt exract agar (MEA) by addition of lipids, proteins or other complex organic substances may suggest preferences to isolate strains infecting animals.

The best techniques for isolation culturing and staining of entomophthoralean fungi for identification were described in Keller's quoted references.

It is very important to preserve microscopic preparations used for studies and identification of these fungi. The majority of their recent descriptions is based on the preparations made in lactophenol with cotton blue. A persistency of materials prepared in this way is good enough to affix mycelium and spores for several dozen years without any changes of measurements. Applying this procedure, however, we obtain weak staining of the nuclei only for some species of the genera *Zoophthora* and *Eryniopsis*. Keller (1987) successfully applied aceto-orcein with lactophenol (LPAO). Except the families of *Ancylistaceae* and *Meristacraceae* for which Feulgen's reaction is recommended, in other groups convenient dyestuffs are aceto-carmine, aceto-orcein and Bismarck brown, but the measurements should be done in lactophenol because of considerable deformations of par-

ticular structures and possible changes in their size (Humber 1976, Ben-Ze'ev & Kenneth 1981, Bałazy — unpubl.). Dry specimens from herbarium materials to be investigated should be previously moistened in damp atmosphere (moist chambers) at least for several dozen minutes, subsequently submerged in lactophenol for one — two hours, and then prepared for microscopy. In such treatment, when careful, the morphological deformations are only slight, if any.

Living cultures of parasitic entomophthoralean fungi may be maintained for very long by being reinoculated every three months or so for continuous cultivation at the temperature of about 20°C or twice a year when they are kept in a refrigerator at +4°C. After long period of culturing, however, some sings of vitality decline may appear (Bałazy 1986). The best practice is to get the obtained cultures down to the specialized laboratories or living cultures collections.

Dead materials should be preserved in some fixative solutions or as microscopic preparations and dry specimens in herbaria. The author's materials are deposited in the collection of the Polish Academy of Sciences, Research Centre for Agricultural and Forest Environment, Poznań, Szeherezady street 74 (ZBS PAN). Useful practice is to mark cartographically particular localities of more important species (Bałazy 1984) since they appear at a definite period almost every year except peculiar or very rare species.

A total number of 226 species have been considered in keys for identification; 114 of them have been reported from Poland. The species hitherto not found in our country have been indicated by numbers in parentheses at their descriptions. The four-figure numbers at some drawings refer to the author note-books and ZBS PAN collection.

ABBREVIATIONS

(in italics – Latin etymology, in parentheses – Polish meaning)

al.	–	*alii,* related to co-authors - „et al." - and others, (i współautorzy).
auct.	–	*auctores*, after different sources, authors, (według różnych źródeł, autorów).
av.	–	average, (średnio).
ca.	–	*circa*, about, (około)
cf.	–	*confer,* compare – related to the species of the closest characteristics, (porównaj – w odniesieniu do gatunku o najbardziej zbliżonych cechach).
comb.	–	*combinatio.* combination, (kombinacja).
comm.	–	communication, message, (informacja, wiadomość).
conf.	–	*confusus, -a, -um*, related to taxonomical name - confusing, ambiguous, (mylący, wieloznaczny, niepewny)
diam.	–	*diametrum,* diameter, (średnica).
dim.	–	*dimensio*, dimension, measurement, (wymiar).
e.g.	–	*exempli gratia*, for instance, (na przykład).
i.e.	–	*id est*, that is, (to jest, to znaczy).
emend.	–	*emendavit* , corrected or essentially supplemented, (poprawił lub w istotnym stopniu uzupełnił).
Fig.	–	*figura*, illustration, (ilustracja, rycina).
herbaria	–	see pages 6–7.
inval.	–	*invalidus, -a, um,* related to taxonomical names - invalid, (nieważny).
media	–	see pages 43–44, 291.
n.	–	*novus, -a, -um,* new, hitherto unknown, (nowy, dotychczas nie znany, nie stosowany).
nom.	–	*nomen,* name, (nazwa).
nud.	–	*nudum*, related to taxonomical names - devoid of descriptive or illustrative characteristics, (bez opisu lub ilustracji).
pers.	–	personal, (osobisty) - related to unpublished direct informations.
p.p.	–	*pro parte,* partially, (częściowo).
preparation	–	see pages 43, 291.
s.l.	–	*sensu lato, latissimo,* in broad sense, (w szerokim znaczeniu).
sp.	–	*species,* one species without indicated binominal, (gatunek bez wskazanej nazwy gatunkowej).
spp.	–	*species* (pl.) two or more species without indicated epithets, (dwa lub więcej gatunków bez wymienionych nazw gatunkowych).
ss.	–	*sensu,* in sense, in meaning, (w rozumieniu, w znaczeniu).
ssp.	–	*subspecies,* subspecies, (podgatunek).
subg.	–	*subgenus,* subgenus, (podrodzaj).
unpubl.	–	unpublished, (niepublikowane).
v.	–	„von" or „van" connected with surname, („von" lub „van" związane z nazwiskiem).
v.d.	–	„van der" connected with surname, („van der" związane z nazwiskiem).
vs.	–	*versus*, contrary to, in opposition to, (w przeciwieństwie do, zamiast).

INDEX OF AUTHORS INVOLVED INTO NOMENCLATURE OF THE ENTOMOPHTHORALES

(Abbreviations marked with asterisk (*) have been used only in index)

Anagnostakis — S. L. Anagnostakis
Anderson — J. F. Andersson
Andreeva — R. V. Andreeva
Arthur — J. C. Arthur
v. Arx — J. A. von Arx
Bail — T. Bail
Bałazy — S. Bałazy
Batko — A. Batko
Beck — G. Beck
Bell — J. V. Bell
Banjamin — R. K. Benjamin
Ben-Ze'ev — I. Ben-Ze'ev
Bernard — E. C. Bernard
Braun — A. Braun
Brefeld — O. Brefeld
Bres. — J. Bresadola
Bubàk — F. Bubàk
Burger — O. F. Burger

Carl — K. P. Carl
Cavara — F. Cavara
Cohn — F. Cohn
Cornu — M. Cornu
Costantin — J. Costantin
Couch — J. N. Couch

Davidson — J. G. Davidson
Descals — E. Descals
Drechsler — C. Drechsler
Dubitskii — A. M. Dubitskii
Dudka — J. A. Dudka
Dunn — P. H. Dunn
Dunphy — G. B. Dunphy
Dustan — A. G. Dustan

Eidam — E. Eidam
Eilenberg — J. Eilenberg
Engler — A. Engler

Fres. — G. Fresenius
Fr. — E. Fries

Garbowski — L. Garbowski
Giard — A. Giard
Gilg — E. Gilg
Gukasjan — A. B. Gukasjan
Gustafs.* — M. Gustafsson

Hall — J. M. Hall
Henneb.* — G. L. Hennebert
Hori — S. Hori
Humber — R. A. Humber
Hutchison — J. A. Hutchison

A. Jacz.* — A. A. Jaczewskii
P. Jacz.* — P. A. Jaczewskii

Kaczmarek — S. Kaczmarek
Keller — S. Keller
Kenneth — R. G. Kenneth
King — D. S. King
Koval — E. Z. Koval
Kramer — J. P. Kramer
Krenner — J. A. Krenner

L. — C. Linnaeus
Lagerh.* — G. V. Lagerheim
Laird — M. Laird
Lakon — G. Lakon
Lavrov — N. N. Lavrov
Lebert — H. Lebert
Li — Li Zengh-Zhi
Lohde — G. Lohde

MacLeod — D. MacLeod
Magnarelli — L. A. Magnarelli
Majmone — B. Majmone
Mande — T. Mande
Mc Clulloch — J. S. McCulloch
Miętkiewski — R. Miętkiewski
Milner — R. J. Milner
Miura — K. Miura

Molliard — H. M. Molliard
Muma — M. H. Muma
Müller-Kögler — E. Müller-Kögler

Nam — E. A. Nam
Narasimhan — M. J. Narasimhan
Nieuwland — J. A. Nieuwland
Nolan — R. A. Nolan
Nowakowski — L. Nowakowski

Olive — E. W. Olive
Oswald — T. Oswald

Papierok — B. Papierok
Pers. — C. Persoon
Peck — C. H. Peck
Petch — T. Petch
Pfitzer — E. Pfitzer
Pohlad — B. R. Pohlad
Porter — J. P. Porter
Povah — A. H. W. Povah

Raciborski — M. Raciborski
Ramakers — P. M. Ramakers
Remaud. — G. Remaudière
Reukauf — E. Reukauf
Richardson — M.J. Richardson
Ringo — S. L. Ringo
Roivainen — H. Roivainen
Rozsypal — J. Rozsypal

Sacc. — P. A. Saccardo
Samson — R. A. Samson
Shimazu — D. Shimazu
Schroeter — J. Schroeter
Smirnova — O. N. Smirnova
Soper — R. S. Soper
Sorokin — N. Sorokin
Speare — A.T. Speare
Srinivasan — M. C. Srinivasan
Staritz — R. Staritz
Swain — A. F. Swain
Syd. — P. Sydow

Thaxter — R. Thaxter
v. Thieghem — P. van Thieghem
Thirum.* — M. J. Thirumalachar
Thoizon — G. Thoizon
Thor — S. Thor
Tucker — B. E. Tucker
Turian — G. Turian
Tyrrell — D. Tyrrell

Uziel — A. Uziel

Viegas — A. P. Viegas
Voseler — J. Vosseler
Vuill. — P. Vuillemin

Webster — J. Webster
Weiser — J. Weiser
Wilding — N. Wilding
Wiśniewski — J. Wiśniewski
Witlaczil — E. Witlaczil
Wize — K. Wize
Wuest — J. Wuest

Yen — D. F. Yen

Zaprometov — N.G. Zaprometov
A. Zimmermann — A. Zimmermann
G. Zimmermann — G. Zimmermann

ORDER *ENTOMOPHTHORALES*

Vegetative mycelium consisting of the hyphae tubular, relatively thick, scarcely or moderately branched, continuous or with sparse cross-walls when young, richly septate and easily fragmented into noncontiguous segments with age or in form of protoplasts and hyphal bodies of subglobose, ovoid, ameboid elongate or polymorphic shapes. Particular cells usually poly- or oligokaryotic, seldom monokaryotic. Propagative sporulation on conidiophores protruding from the hyphal bodies or as specialized and often morphologically differentiated branches of the hyphae. Primary conidia unicellular mono-, oligo- or polykaryotic, produced singly as terminal vesicles of particular conidiogenous cells terminating simple or branched conidiophores or on special conidiogenous cells arranged axially or laterally on the conidiophores; ripe conidia forcibly discharged by special mechanisms based on the differences of the osmotic pressure between the conidium and conidiogenous cell; only in two genera these mechanisms do not function and the primary conidia are passively detached. Several types of secondary conidia commonly occur, i.e. of the ballospore type secondary conidia like the primary or of different shape and microconidia, elongate secondary conidia of reduced discharge mechanism, and capilliconidia. In the genus *Basidiobolus* some cells of vegetative mycelium or secondary conidia of the capillispore type may function as sporangia producing a number of monokaryotic sporangiospores. Resting spores produced in result of sexual process of gametangiogamy, where particular hyphal cells, hyphal bodies or special conjugative outgrowths may function as gametangia. Zygospores globose to ellipsoid or polyhedral, thick-walled, hyaline or coloured, of the surface smooth, ornamented, warty or spinulose. In many species the sexual process does not occur and the resting spores are produced as azygospores, morphologically indistinguishable from the zygospores. The resting spores germinate with one or more hyphae producing adhesive conidia (so called „germ conidia") or may form capilliconidia in some species. Chlamydospores occur in many species.

Pathogens of invertebrate animals, most frequently of arthropods, accidentally also in vertebrates including warm-blooded animals and man; rarely pathogens of algae, fern gametophytes and higher fungi or saprophytes in organic matter. Mostly terrestial forms although often connected with habitats of relatively high humidity or with moist sites; the *Ancylistes* species occur only in waters.

Up to date there are known over 200 species arranged into six separated families. With regard to the practical interpretation and diagnostic difficulties the species counted by B e n-Z e' e v et al. (1987) and H u m b e r (1989) to the

families *Neozygitaceae* and *Completoriaceae* have been left in the family *Entomophthoraceae*. It should not however, be treated as rejection of the validity of these two families. According to Humber's (1989) opinion the transfer of the genus *Macrobiotophthora* to the family *Ancylistaceae* has been maintained but for the reason of poor and rather hardly accessible references concerning this genus it is also included in the key for identification of the genera in *Entomophthoraceae*. There has been maintained the division of the genus *Zoophthora* into 4 subgenera proposed by Batko (1966) including some later corrections and changes (Remaudière & Hennebert 1980, Humber & Ben-Ze'ev 1981, Ben-Ze'ev & Kenneth 1982, Li & Humber 1984) except Humber's (1989) elevation of these subgenera to the generic rank.

Key to Families

1. Conidia and conidiogenous structures unknown; resting spores present . . . . . *Tarichium*, p. 250
1*. Conidiogenous structures and conidia present; resting spores present or absent 2

2. Nuclei basidioboloid; mycelium dividing soon into monokaryotic segments; conidiophores unbranched, strongly inflated in subapical part, form single conidia ejected by „sporophore rocket" mechanism together with the terminal part of the conidiophore; conjugation between neighbouring cells of the same hypha with beak-like adjacent outgrowths; sporangiospores may be produced in some vegetative cells and in capillispores; saprophytes, occasionally animal parasites . *Basidiobolaceae*, p. 51
2*. Nuclei of another type; cells of mycelium usually oligo- or polykaryotic, seldom monokaryotic; cross-walls in hyphae irregularly distributed; sporangiospores do not occur; gametangial cells without charcteristic beaks 3

3. Nuclei entomophthoroid; conidiophores simple, furcate or digitately branched at ends; primary conidia terminally formed and rejected by „papilla eversion" or „sporophore cannon" mechanisms; conjugation isogametangiogamous, frequent cases of azygospore production; specialized parasites of invertebrate animals, one species phytopathogenic in fern gametophytes . . . . . *Entomophthoraceae*, p. 93
3*. Nuclei ancylistoid 4

4. Primary conidia formed singly terminally and discharged by „papilla eversion"; conidiophores simple, exceptionally with single irregular

branch; parasites of desmid algae, higher fungi, arthropods and warm-blooded vertebrates or saprophytes in organic matter . . . . . *Ancylistaceae*, p. 57

4*. Primary conidia formed singly laterally on particular cells of septate conidiophores and clustered by several to several dozen or produced terminally in acropetal succession on sporogenous cells or short sterigma-like denticles arranged laterally on conidiophores, forcibly discharged or passively detached; parasites of nematodes, tardigrades and insects . . . . . *Meristacraceae*, p. 87

FAMILY *BASISIOBOLACEAE* Engler et Gilg

Basidiobolaceae Engler et Gilg, Syll. Pflanzenfam. p. 45. 1924.

Vegetative mycelium as hyphae more or less regularly divided on to monokaryotic segments or hyphal bodies, multiplicating by mitosis and plasmotomy. Nuclei large, spherical of the diameter usually greater than 5 μm, or elongate, with conspicuous and relatively big nucleolus, weakly staining with aceto-orcein and Bismarck brown. Conidiophores unbranched, in subapical part strongly inflated, and with terminal part thrown out together with the conidium at the moment of ejection by the mechanism of „sporophore rocket". Primary conidia globose with slightly convex and relatively short papillae, monokaryotic of unitunicate (or cryptobitunicate) wall. Secondary conidia ballospores similar to the primary ones, capillispores, microconidia of the type *B* (see p. 25) and sporangiospores. Conjugation between two neigbouring cells with beak-like adjacent outgrowths (Fig. 12) of the same hyphae; zygospore forms inside the recepting cell.

Saprophytes on different organic matter mostly in early stages of decomposition, in alimentary canal and excrements of frogs and lizards, occasionally pathogens of insects, warm-blooded animals and man, particularly in subtropical and tropical regions.

One genus was decribed up to date although in collections are materials permitting to suppose somewhat greater range of taxa belonging to this family (Humber 1989).

Genus *Basidiobolus* E i d a m

Basidiobolus E i d a m, Beitr. Biol. Pflanz. 4: 183-251. 1886.

The description does not differ from the family characteristics.

Despite rich literature concerning mainly subcutaneous mycoses caused by the fungi of this genus, there is no good critical taxonomical revision of the species hitherto described. From among 9 species epithets under this generic name different authors consider the majority of them to be synonyms of *B. ranarum*, but their conclusions are not equivocal. Remarks presented below the descriptions of four species included in the key for species have been quoted to stress possible diversity or variability. According to revised data only one species should be considered as reported from Poland.

Type species: *Basidiobolus ranarum* E i d a m.

Key to species

1. Surface of zygospores smooth 2
1*. Surface of zygospores wavy 3
2. Aerial mycelium in cultures lacking, colonies indistinct with not numerous conidiophores . . . . . *B. haptosporus*, p. 55
2*. Aerial mycelium in cultures abundant with numerous conidiophores . . . . . *B. meristosporus*, p. 55
3. Microconidia present forming exogenously from the primary conidia; colonies without odor characteristic for *Streptomyces* . . . . . *B. microsporus*, p. 56
3. Microconidia lacking; colonies with distinct benzene hexachloride odor characteristic for *Streptomyces* . . . . . *B. ranarum*, p. 52

1. *Basidiobolus ranarum* E i d a m

Basidiobolus ranarum E i d a m, Beitr. Biol. Pflanz. 4 (2): 194-239. 1886.

Development in artificial cultures variable depending on strain and composition of media. Colonies on SDA and SAEY dense of cerebriform or radially furrowed surface, at first white to cream or yellowish, becoming light brown with age, growing fairly rapidly in the superficial layer of the media, attaining the diameter 6-10 cm in two weeks at about 20°C. Reverse uncoloured. Typical aerial

Fig. 12. *Basidiobolus ranarum*: a — monokoryotic hyphal segment, b — conidiophore, c — a capillispore and ballospores, d — conjugating cells and young zygospores.

hyphae scarce, mostly as single, unbranched conidiophores stretching up to 150-200 µm over the compact layer of substrate mycelium. Colonies on PDA plane, rather thin, without furrows but with more numerous conidiophores giving the colony surface dilute velvety whitish appearence, smaller — up to 3-4 µm in diam. after two weeks. Strong *Streptomyces*-like odor produced in cultures. Mycelium consists of moderately richly branched hyphae 8-15 µm thick, divided by numerous septa on monokaryotic segments about 50-130 (-150) x 12-28 µm, often disjoining or separated by sections devoid of protoplasm. Terminal parts of the hyphae in the young colony margin usually weakly branched and longer, 150-300 µm x 8-15 µm. Nuclei large, typically basidioboloid, globose, 6-9 µm in diam., with great nucleolus of the diam. 4-5 µm, or elongate (ellipsoid to obtuse fusiform), 8-12 x 5-8 µm, then nucleoil also ovoid 4-7.5 x 3.5-5.5 µm. Primary conidiophores unbranched, 300-400 or more µm long, 4-7 µm thick except the inflated subapical parts which are 25-35 µm long and 12-15 µm thick. Primary conidia globose, 23-48 µm in diam., with weakly marked papilla usually pointed in the center of its concavity. Secondary conidia similar, regularly smaller and smaller, produced on secondary conidiophores resembling those primary ones but much shorter. Capillispores of the haptospore type, strongly elongate and bilaterally symmetric, with terminal elongation 3-5 µm long, ended by a rounded drop of opaque adhesive substance. The dimensions of their first series range between 65-85 µm x 21-24 µm. whereas the subsequent series are gradually smaller and smaller, dropping even to about 25 x 10 µm. Capillary sporophores usually straight, 60 to over 200 µm long, 2-2.5 µm thick at the base and 1-1.5 µm thick at the end. Zygospores 31-38 µm in diam., surrounded by walls 3-4 µm thick of roughly and unevenly wavy epispore, formed usually in axial alignment inside one parental cell (Figs. 2 and 12).

Distribution and substrates. All continents, in amphibian and reptilian excrements, soil and organic detritus; in one case isolated from horse leg scretch.

Occurrence in Poland. Common species, reported from Silesia, Cracovian regions, Białowieża Forest, Wielkopolski National Park, Poznań and Turew near Leszno.

Remarks. The description given above has been based on strains obtained from *Bufo bufo* L. excrements in the Professor L. Berger rearing at the Research Center for Agricultural and Forest Environment of the Polish Academy of Sciences. However, they are identical with numerous strains from Białowieża, and Wielkopolski National Park isolated earlier as contaminants of entomophthoealean cultures (*Zoophthora* spp., *Entomophaga tipulae*, *Eryniopsis caroliniana* and others) from insects collected in moist habitats. One of these strains, isolated from a big fly (probably of the family *Sarcophagidae*) infected by *Zoophthora ovispora* (Nowakowski) Batko and sent to the collection of the Boyce Thompson Research Institute for Biological Control at the Cornell University, Ithaca, USA was determined as *Basidiobolus haptosporus* Drechsler (Humber & Soper 1984). According to hitherto accessible characteristics the only real difference between *B. ranarum* and *B. haptosporus* is the smooth epispore of the zygospores in the latter. Coremans-Pelseneer (1974) treated *B. myxophilus* Fries (1899) and *B. heterosporus* Srinivasan

et Thirumalachar (1967) as synonyms of *B. ranarum*, whereas *B. magnus* Drechsler (1964) and *B. microsporus* Benjamin (1962) as very close to or identical. As concerns the latter, its ability to produce exogenic microspores seems to be a sufficiently distinctive feature to separate the species.

(2.) *Basidiobolus haptosporus* Drechsler

Basidiobolus haptosporus Drechsler, Bull. Torrey, Bot. Club 74: 411. 1947.

Colonies growing well at room temerature, producing poor netwoork of aerial hyphae and dense, thick layer of submerged mycelium of cerebriform surface. Diameter of the hyphae uneven, particular cells in older cultures of rounded angles and easily separating. Conidiophores and primary conidia not numerous, similar to these of *B. ranarum*. Secondary ballospores similar, smaller. Capilliconidia of the first series some 50-65 x 13-18 μm, of regularly arcuate convex dorsal side and the ventral one almost straight or indistinctly concave beginning from 1/3 of their length, terminated with 5-8 μm long, thin cylindric elongation with subglobose gluey haptor at end; the capillispores of subsequent series gradually smaller and smaller. Capillary sporophores about 100-270 μm long. Zygospores subglobose and globose, 23-37 μm in diam., surrounded by walls up to 3 μm thick, smooth. In the deeper parts of submerged mycelium ovoid to elongate chlamydospores 30-70 x 20-30 μm are produced in older cultures.

Distribution and substrate. North America (USA, Wisconsin), in deciduous forest litter; similar fungus of a little smaller zygospores has been described as a variety *B. haptosporus* var. *major* Srinivasan et Thirumalachar, (1967) from India.

Remarks. The culture nr. 1580b isolated from a fly infected by *Zoophthora ovispora* (Nowakowski) Batko in the Wielkopolski National Park has been identified by Soper and Humber (1984) as *B. haptosporus*, however it does not differ from the others treated here as *B. ranarum* (see „Remarks" in the description of *B. ranarum*, p. 54).

(3). *Basisiobolus meristosporus* Drechsler

Basidiobolus meristosporus Drechsler, J. Washington Acad. Sci. 45: 49-56. 1955.

Mycelium on the maize extract agar grows fairly rapidly producing a dense felt of segmented hyphae in the superficial layer of the medium and readily visible colourless aerial hyphae. No odour of benzene hexachloride produced. Particular segments of the assimilative hyphae monokaryotic, 30-230 x 3-20 μm, easily separating. Primary conidiophores arise from the hyphal segments or from germinating zygospores, 60-200 μm long, 4-9 μm wide, with the distal part inflated into an

elongated swelling 35-60 x 15-30 μm. Primary conidia globose, 20-45 μm in diam., with slightly marked papillar convexity. Secondary conidiophores and ballospores similar to the primary ones. Capilliconidia elongate bilaterally symmetric, 20-70 x 6-20 μm, with the distal end elongated into an almost straight, beak-like haptor 3-10.5 x 1-2.7 μm, covered with a drop of glutineous substance. Capilliphores straight, mostly 75-200 μm long and 1.5-3.5 μm wide at the base, steadily attenuating upwards up to 1-2 μm near the tip. The content of both the primary and all types of the secondary conidia may easily divide on a number of uninuclear sporangiospores which liberate by spore wall ruptures. Zygospores globose or ellipsoid, 23-35 x 20-32 μm, surrounded by smooth, yellowish wall 2-3 μm thick.

Distribution and substrates. The species originally described from Florida, later recognized as widely distributed in all tropical and subtropical regions. Common in organic detritus lezard excrements and as warm-blooded animals and man subcutaneous mycose agent. Not reported from Poland.

Remarks. According to Coremans-Pelseneer (1974) *B. meristosporus* seems to be the only species causing mycoses of warm-blooded and her analysis of the basidiobolomycose distribution indicates few cases of this disease in Poland or neigbouring countries. However the disease agents have not been identified as *B. meristosporus*. On the other hand there have been numerous confusions or inaccuracies in *Basidiobolus* species identification, so one can expect some new data or corrections as concerns their ecology and distribution. For instance Soper and Humber (1974) recommend particular caution at the work with the species *B. haptosporus* as a potential human mycose agent, contrary to Coremans-Pelseneer (1974) conclusion. For the same reasons the possibility of an appearence of *B. meristosporus* in Poland cannot be excluded.

(4). *Basidiobolus microsporus* Benjamin

Basisibolus microsporus Benjamin, Aliso 5 *(2)*: 225-232. 1962.

Colonies on yeast extract soluble starch agar (Benjamin 1962: 226) colourless but distinct. Vegetative hyphae branched, 8-20 μm in diam., divided by cross walls into uninucleate segments 30-200 μm long; terminal cells of submerged hypae often longer — 600-700 μm whereas the hyphal segments near the surface — in the conidiophore formation layer — are shorter and up to 15-40 μm wide. Conidiophores 200-500 μm long and 7-16 μm wide, strongly distended in subapical part, 50-80 μm long and 20-36 μm thick. Primary conidia globose 28-41 μm in diam., with slightly convex basal papilla. Secondary ballospores of the same type. Capilliconidia narrow-elongate about 45-80 x 15-19 μm, with distal part narrowed into much thinner beak, ended with viscous haptor; capillary sporophores upright, slender, 200-320 μm long, about 3-4.5 μm wide at base slightly attenuating towards apex. Microspores formed terminally on thin pedicels 5-10 (-20) μm long, protruding radially from primary or secondary ballospores in number 8-60;

they are uninucleate, with ovoid or ellipsoid basal part 7-11 x 4.4-6.6 μm, attenuating into thin, aristate apical projection 7-28 μm long and 1.3-2.2 μm wide at the base (Fig.9). Zygospores globose 20-44 μm in diam. or ovoid 22-52 x 20-42 μm, surrounded by walls 2-7 μm thick of wavy surface, originating by fusion of two adjacent cells of mycelium or ballospores.

Distribution and substrates. North America (California), isolated from dung of a small animal and duff beneath nest of pack rat.

Remarks. Coremans-Pelseneer (1976) expressed the opinion that except peculiar type of microspores formation this species does not differ from *B. ranarum*.

FAMILY *ANCYLISTACEAE* v. Thieghem

Ancylistaceae v. Thieghem, Traité de Botanique: 1007. 1884.

Mycelium consisting of the hyphae continuous or septate, with age often divided into noncontiguous polykaryotic hyphal segtments or polymorphic hyphal bodies. Nuclei ancylistoid less than 3 μm in diam., not staining in Bismarck brown, weakly staining in aceto-orcein and other common nucleus colouring stuffs. Conidiophores hypha-like or more or less distended in subapical part, unbranched, sporadically furcate or with single irregular and not typical branches. Primary conidia subspherical or globose with conical or convex papillae, or obovoid to pear-shaped, usually polykaryotic, formed singly terminally on the conidiophores and forcibly ejected by round off of the papillae, often on relatively long distance, even over 3 cm. Secondary conidia ballospores of the same type as the primary ones and microconidia, elongate non-adhesive conidia of retarded ejection mechanism and capilliconidia. Zygospores round, ellipsoid, elongate or of less regular shapes, covered by the wall smooth or ornamented, hyaline or coloured, formed inside the recepting gametangium, arranged in axial alignement with, or laterally to conjugating hyphal segments. The primary or secondary ballospores may transform into a kind of resting spores (so called loricoconidia) by thickening of their walls and loss of papillae. Chlamydospores often present. Parasites in desmid algae (only species of *Ancylistes*), saprophytes in soil, litter and organic detritus, pathogens of arthropods and rarely of other small invertebrates, also isolated from old fruit-bodies of higher fungi and in cases of systemic mycoses and dermatophytoses of warm-blooded animals and man.

Three genera have been counted into this family.

Key to genera

1. Terrestrial forms of abundant mycelium, developing saprophytically or parasitizing in arthropods and warm-blooded vertebrates or on fruit bodies of higher fungi . . . . . *Conidiobolus*, p. 60
1*. Parasites of small organisms living in water or in moist habitats, producing not numerous infective hyphae or conidiophores on host's surface 2
2. Parasites of desmid algae; the infective hyphae emerging over water surface transform into conidiophores . . . . . *Ancylistes*, p. 58
2*. Parasites of nematodes or tardigrades; conidiophores growing from internal mycelium by the typical way . . . . . *Macrobiotophthora*, p. 86

Genus *Ancylistes* Pfitzer

Ancylistes Pfitzer, Monatsb. Konigl. Preuss. Akad. Wiss., Berlin 396. 1872.

Mycelium hyphal, develops inside an alga cell; hyphae at first continuous, with age septate and usually constricted at the cross-walls, with particular segments easily separating. Single hyphae perforate host's cell wall and develop outside as so called „infective hyphae" with their tips selectively adhesive to the potential host wall surface. In case of contact with water surface they transform into distended sporogenous cells forming the conidia ejected to the air by papilla eversion. Zygospores spherical or ovoid, formed inside the host body as result of anisogametangiogamy, in hitherto known species brown, smooth. Parasites in desmid algae.

Type species: *Ancylistes closterii* Pfitzer.

Key to species

1. Walls of female gametangia without tumourous, wart-like convexities; hyphal segments almost equally narrow or slightly constricted at cross-walls 2
1*. Walls of female gametangia with distinct tumorous wart-like convexities; hyphal segments steadily constricted in central parts and obtusely rounded at ends; primary conidia globose, 22.2-30 µm; zygospores 18.5-22 µm in diam.; parasite in *Closterium* spp. . . . . *A. pfeifferi*, p. 60
2. Zygospores 14.5-20 µm in diam. developing in outgrowths of female ga-

metangia; primary conidia with narrow papilla up to 5 μm long; parasite in *Closterium* spp. . . . . *A. closterii*, p. 59

2*. Zygospores 25-29.5 μm in diam. developing in conjugative bridges; primary conidia globose 15-25 μm with conical papillae; parasite in *Netrium digitus* . . . . . *A. netrii*, p. 59

(1). *Ancylistes closterii* Pfitzer

Ancylistes closterii Pfitzer, Monatsb. Konigl. Preuss. Akad. Wiss. Berlin: 396. 1872.

The hyphae filling host's cells at first continuous 7-11 μm diam., later septate, with particular segments distended in the middle, 12.5-55 x 11-15 μm, growing through the host's cell wall produce relatively thin and long infective hyphae, 3-7.5 μm thick, which in contact with the air may function as sporophores forming each one terminal primary conidium, 13.5-17.5 μm in diam., with about 5 μm long papilla. Spore discharge by papilla eversion. Zygospores smooth, globose, brown, thick-walled, 14.5-20 μm diam., originating as a result of conjugataion of unequal gametangia and forming in greater gametangium; the latter without protuberances or swellings in outline.

Distribution and hosts. Original record — Germany near Bonn, obligate parasite of *Closterium acerosum* (Schrank) Ehrenberg ex Ralfs, also reported from Central and Southern Europe, Central Asia and Southern States of USA, as the parasite in *Closterium* spp.

(2). *Ancylistes netrii* Couch

Ancylistes netrii Couch, J. Elisha Mitchell Sci. Soc. 65: 131. 1949.

Young hyphae filling the host cells aseptate, 2.2-4.8 μm thick, dividing with age into cells 15-30 x 8-15 μm. The exit hyphae protrude as perpendicular, rather thin branches. Particular hyphal cells, 2-4 μm thick in basal half, above swollen to 4-9 μm and perforating host's cell wall by thinner tube. After contact of a host with water surface such hyphae produce the external somewhat clavate sporophores, about 25-100 μm long and 8 μm thick.Primary conidia 16-25 μm diam., with short, conical papillae. Zygospores forming in conjugating tubes, globose or subglobose, av. 19-26 μm diam., the largest 25 x 29.5 μm, with walls up to 2.5 μm thick, smooth,

Distribution and hosts. North America, USA — North Carolina, in *Netrium digitus* (Ehrenberg) Itzigsohn et Rothe.

(3). *Ancylistes pfeifferi* Beck ex Tucker

Ancylistes pfeifferi Beck, Verh. Zool-Bot. Ges. Wien, 46: 233. 1896; — Tucker, Mycotaxon 13: 493, 1981.

Hyphae filling the host cells at first continuous, 7.5-14 µm thick, dividing by septa into segments 43-67 x 9.5-19 µm usually the thickest at their ends (bone like). Externally growing sporophores usually 4-7 µm thick producing globose primary conidia 21-23.5 µm diam., with papillate base. Zygospores smooth globose, brown, thick-walled, 18.5-22 µm, forming in greter gametangium; the latter with some protuberances or assymmetrical swellings in outline.

Distribution and hosts. Europe, North America, parasite in cells of *Closterium* spp.

Remarks. Batko (1974b) considers the name *Acylistes berdani* Sparrow as a synonym of *A. pfeifferi.*

Genus *Conidiobolus* Brefeld

Conidiobolus Brefeld, Untersuch. Ges. Mycologie 6: 35-72, 75-78. 1884.

Mycelium consisting of tubular hyphae at first without cross walls or sparingly septate, segmenting and becoming uncontigously fragmented with age, forming elongate, ameboid or polymorphic hyphal bodies. Conidophores unbranched or exceptionally with one or two irregular branches, hypha-like or distended in subapical part. Primary conidia polykaryotic, unitunicate (or cryptobitunicate), globose, subspherical, ovoid or pyriform with semispherically convex or conical papillae, which are obtuse or pointed. Secondary conidia similar to the primary ones and microconidia, rarely also secondary conidia of retarded ejection mechanism and capillispores. Zygospores round ovoid, ellipsoid or of less regular shapes, smooth, rough or echinulate, hyaline or coloured, forming in result of anisogametangiogamy inside the recepting gametangium. In some species gametangiogamy has not been stated so the resting spores are considered to be azygospores. Chlamydospores often occur in vegetative mycelium especially in older colonies. In some entomopathogenic species rhizoids monohyphal or interwoven into pseudorhizomorph-like structures occur in natural hosts. Saprophytes in soil, litter and organic detritus, parasites in fruit bodies of higher fungi, pathogens of arthropods, seldom of warm-blooded animals and man.

Type species: *Conidiobolus utriculosus* Brefeld.

Most of hitherto described species are known from North America and South-

Eastern Asia where in the last half-century more extensive studies on these fungi have been carried out. King (1977) listed 27 valid species names after the recent comprehensive revision of this genus. Ben-Ze'ev and Kenneth (1982) added further 4 names including three entomopathogenic species recorded earlier under the generic names *Empusa* or *Entomophthora* s.l. After detailed comparative studies of karyological characteristics two from among them were icluded again into the family of *Entomophthoraceae* (see *Batkoa apiculata* and *Batkoa major* p.p.), whereas *Entomophthora destruens* Batko et Weiser was transfered to *Conidiobolus* (Ben-Ze'ev 1982) and three new species were described (Bałazy et al. 1987, Keller 1991). One new species has been described in this review, so the actual number of considered species is 34. Data from Poland are fragmentary: several species have been reported as result of investigations on the fungi of forest litter, on mycoses of arthropods and cases of systemic mycoses of men. In face of generally wide distribution, however, the majority of hitherto described species and possibly a number of new ones occur undoubtedly in Poland.

Because of high degree of morphological similarity of the *Conidiobolus*-species considered to be saprophytic with the entomopathogenic *Entomophthoraceae* the precinct of this genus was poorly determined till the moment of corroboration of the karyological criteria. So e.g. Kevorkian (1937) suggested to iclude them into the genus *Entomophthora* sensu latissimo, whereas other investigators (Srinivasan & Thirumalachar 1967, Batko 1974, King 1976 b) were inclined to ascribe the character of feature criterion to their insect pathogenicity vs. sapropytism. In their tour Remaudière and Keller (1980) proposed to include all entomophthoralean forms of spherical, ovoid and pyriform unitunicate and multinucleate conidia to the genus *Conidiobolus*. As a result almost all species of *Entomophaga* Batko emend. Humber and later separated *Batkoa* Humber have been listed under this name. Developing the idea of Tyrrell and MacLeod (1972) and analysis of Humber's (1981) taxonomical criteria Ben-Ze'ev and Kenneth (1982) proposed to divide this genus into three subgenera on the basis of peculiar forms of secondary conidial sporulation; this treatment is accepted in the present paper. However, revisions of Srinivasan and Thirumalachar (1967) and King (1976 a,b, 1977) considered under this name only saprophytic and accidentally pathogenic species, showing the ability to develop in vitro on relatively simple and commonly applied media. The majority of typically entomopathogenic species were included in recent years and data on their development in cultures were either lacking or incomparable with King's description because of different methods. So the arrangement of keys in this book has been compiled after quoted reviews and other references containing original observations on newly separated or icluded species. It is worthy to stress the suthor's opinion (Bałazy et al. 1987) — recently accepted by some specialitsts, e.g. A. A. Callaghan (pers. comm.) —

that the majority of species isolated by Drechsler and Indian mycologists from forest litter and soil detritus, originate most probably from small invertebrates inhabiting these habitats.

Key to subgenera

1. Typical multiplicative resporulation by microconidia produced from primary or secondary conidia occur . . . . . subg. *Delacroixia*, p. 75
1*. Microconidia absent — at most two to three secondary conidia resembling primary ones produced from one primary conidium 2
2. Capilliconidia produced . . . . . subg. *Capillidium*, p. 83
2*. Capilliconidia not produced . . . . . subg. *Conidiobolus*, p. 62

Subgenus *Conidiobolus* Ben-Ze'ev et Kenneth

Conidiobolus subg. *Conidiobolus* Ben-Ze'ev et Kenneth, Mycotaxon 14: 429. 1982

Secondary conidia of the type of ballospores similar to the primary ones or else elongate of retarded ejection mechanism. Microconidia and capilliconidia lacking. Rhizois present in few entomopathogenic species.

Type species: *Conidiobolus utriculosus* Brefeld.

Key to species

1. Entomopathogenic species forming rhizoids on infected arthropods . 2
1*. Saprohytic or zoopathogenic species; if entomopathogenic — not producing rhizoids on infected hosts 3
2. Rhizoids thin, mononematous or loosely interwoven, without disc-like holdfasts or irregularly branched outgrowths at ends; primary conidia ovroid or pyriform, 22-31 x 18-24 μm, with rather small convex papillae; on adults of *Culicidae* in cool and humid habitats . *C. destruens*, p. 65
2*. Rhizoids densely interwoven into fasciculate or tissue-like, flattened pseudorhizomorph-like structures with irregularly branched terminal outgrowths forming holdfasts; primary conidia pear-shaped, (31) 33-39 (-41) μm in diam., with semispherical papillae 6-8 μm long and 12-18 μm wide; not developing on any artificial media; pathogen of *Ectobius lapponicus* in clear pine forests . . . . . *C. gustafssoni*, p. 66

3. Species well recognized and characterized in artificial cultures by K i n g (1976, 1977) or after his methods 4
3*. Entomopathogenic species not cultured or of incomplete characteristics in artificial cultures, making impossible comparisons with King's descriptions 21

4. Conidiophores strongly distended, 3-4 times thicker than vegetative hyphae 5
4*. Conidiophores not distended or at the outmost two times thicker than vegetative hyphae 6

5. Primary conidia spherical 15-46 x 13-45 µm with broadly convex papilla, 2-6 x 5-17 µm, of obtuse end; resting spores lacking; subspherical or ovoid chlamydospores, 15-46 x 13-40 µm, may occur in submerged mycelium . . . . . *C. adiaeretus*, p. 70
5*. Primary conidia subspherical to pyriform, 20-25 x 12-18 µm, with small conical papilla 2-4 x 3-6 µm; zygospores globose, smooth, 12-18 µm in diam.; chlamydospores lacking . . . . . *C. bangalorensis*, p. 68

6. Zygospores smooth or if rough, very big, about 60 µm in diam., and formed laterally to longitudinal axis of conjugating hyphal segments or colonies produce the odor of benzene hexachloride; passively detached secondary conidia do not occur 7
6*. Zygospores absent or, if present, they are rough, of the diameter not exceeding 35 µm, and formed in axial arrangement with the conjugating hyphal segments; passively detached secondary conidia may occur . 16

7. Elongate secondary conidia forcibly discharged occur; chlamydospores present or lacking 8
7*. Elongate secondary conidia forcibly discharged and chlamydospores lacking 9

8. Primary conidia subglobose to broadly ellipsoid, 15-54 x 14-45 µm; chlamydospores present . . . . . *C. eurymitus*, p. 68
8*. Primary conidia ovoid, 12.5-27 x 10-16 µm, with short, rather broad papillae; chlamysospores unknown . . . . . *C. couchii*, p. 69

9. Primary conidia small, ca. 19 x 17 µm, the greatest not exceeding 22 x 20 µm; conidiophores not distended 10
9*. Primary conidia greater, ca. 27 x 22 µm, the gratest 32 x 26 µm, if smaller then conidiophores distended 12

10. Zygospores usually ellipsoid 21-30 x 17-22 µm, formed in axial arrangement with the conjugating hyphal segments; gametangia distnct, deriving from the adjacent cells of the same hypha . . . . *C. khandalensis*, p. 69

10*. Zygospores usually globose 7-18 µm in diam., formed axially or laterally, if greater and ellipsoid then gametangia indistinguishable 14

11. Three day old colonies on PDA at 21°C dense, opaque; zygospores globose, smooth, formed along the axis of one or both conjugating segments of hyphae; gametangia distinct . . . . . *C. lamprauges*, p. 69
11*. Three day old colonies on PDA at 21°C dilute, transparent; zygospores globose, smooth and rough — formed laterally, and ellipsoid — arranged axially; gametangia indistinct . . . . . *C. paulus*, p. 70

12. Zygospores 55-60 µm long; vegetative hyphae about 16 µm thick . . . . . *C. utriculosus*, p. 74
12*. Zygospores about 40 µm long; vegetative hyphae about 10 µm thick 13

13. Zygospores smooth; mycelium loose 14
13*. Zygospores rough, if smooth then mycelium compact, at least in zones of sporulation 15

14. Protoplasm of primary conidia contains in central part compact, big globules surrounded by finely granular cytoplasm; zygospore walls up to 3.5 µm thick . . . . . *C. thromboides*, p. 72
14*. Protoplasm of primary conidia finely granular, sometimes with greater globose granules regularly overspread in all conidium content; zygospore walls up to 5.5 µm thick . . . . . *C. megalotocus*, p. 81 subg. *Delacroixia*

15. Zygospores rough, single ones smooth may occur; colonies often with odor of benzene hexachloride; mycelium rather loose *C. osmodes*, p. 71
15*. Zygospores smooth; cultures without distinct odor; mycelium compact at least in zones of sporulation . . . . . *C. stromoideus*, p. 72

16. Villose resting spores occurring . . . . . *C. coronatus*, p. 78 subg. *Delacroixia*

16*. Villose resting spores absent 17

17. Chlamydospores present; zygospores lacking 18
17*. Chlamydospores lacking or appearing in over one month old cultures; zygospores smooth 20

18. Chlamydospores regularly globose; conidiophores shorter than 100 µµ . . . . . *C. lachnodes*, p. 71
18*. Chlamydospores elongated of rather variable shapes; lenght of conidiophores variable 19

19. Chlamydospores globose or barrel-shaped; length of conidiophores variable, but usually over 200 µm . . . . . *C. firmipilleus*, p. 79 subg. *Delacroixia*

19*. Chlamydospores about 45 µm long of variable shapes; lengths of conidiophores less differentiated, usually up to 75 µm *C. multivagus*, p. 73

20. Conidiophores as thick as hyphae or indistinctly thicker; protoplasm left in the conidiophore after discharge of conidium forms a functioning cell . . . . . *C. firmipilleus*, p. 79 subg. *Delacroixia*

20*. At least a part of conidiophores distinctly thicker than vegetative hyphae; chlamydospores lacking; residues of protoplasm do not form a living cell after conidium discharge . . . . . *C. megalotocus*, p. 81 subg. *Delacroixia*

21. Strains not cultured, morphology known only from infected arthropods; primary conidia globose, 34-45 µm in diam., with long conically tapered papilla 7-14 x 8.5-15.6 µm, pointed at tip; pathogen of the mite *Pergamsus* sp. (*Acari: Gamasida*) . . . . . *C. chlapowskii*, p. 75

21*. Entomopathogenic species also cultured on media; primary conidia about 28-35 µm in diam.; papilla abruptly protruding, semispherical, obtuse; on aphids . . . . . *C. obscurus*, p. 73

1. *Conidiobolus destruens* (Weiser et Batko) Ben-Ze'ev et Kenneth

Conidiobolus destruens (Weiser et Batko) Ben-Ze'ev, Mycotaxon 16: 229.1982 — *Entomophthora destruens* Weiser et Batko, Fol. Parasitol. (Praha) 13: 144-149. 1966.

Vegetative hyphae divided by not numerous cross-walls onto multinucleate hyphal segments and later disjoined on less regular hyphal bodies. Conidiophores unbranched, hypha-like. Primary conidia ovoid or pyriform, 22.5-31 x 18-24 µm, with rather small and narrow, obtusely convex papillae 1.5-4.5 µm long and 5-10 µm wide at the base, exceptionally with weakly marked point in the center. Secondary conidia like the primary — both transform easily into thick-walled resting spores (loricoconidia), hardly distinguishable by small papillar protrusion from those formed abundantly inside and on the surface od infected insects among the hyphae and hyphal bodies, 24-33 µm in diam., surrounded by the transparent wall 2-3.5 µm thick of smooth surface. Host attached by numerous monohyphal rhizoids about 5-20 µm wide, often furcate or with several short irregular branches prostrating on the substrate.

Distribution and hosts. Central and Western Europe, on *Culex pipiens* L. and possibly other mosquitoes hibernating in caves, shelters and cellars. In Poland known from Siemianice near Kępno and Trzemeszno near Gniezno, on hibernating *Culicidae* (author's records).

Remarks. The fungus is probably much more common and distributed, however, peculiar places of its occurrence are seldom investigated in this respect. Weiser and Batko (1966) cultured it on egg yolk and some other media, but characteristics of artificial cultures have not been given.

2. *Conidiobolus gustafssonii* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia amoebiformia et polymorpha dimensionibus 40-150 x 18-30 µm cum appendicibus et convexitatibus vesicularibus. Hyphae 9.5-15 µm crassae, aequo-angustae. Cellulae conidiogenae clavatae, dimensionibus 95-165 x 18-25 µm. Conidia primaria ovata vel piriformia, in dimensiones (39-) 41-47 (-52) x (29-) 32-40 (-44) µm, ad basim, in ut, ita dicam, superpapillare collum 12-17 µm latum, 3-4 µm longum coartata; papilla 4-7 µm longa, saepe cum tenero aculeo centrali. Conidia secundaria primariis similia, minora. Rhizoidea aequo-angusta, taeniolaeformia, valde in pseudorhizomorpha contexta, inter hospitis thoracis ventralis sclerita largiter excrescunt. Sporae perdurantes ignotae. Specificus parasitus insecti Ectobius lapponicus* De Geer.

Holotypus. *Specimen numero 1922-1 in collectione* ZBS PAN *designatum, die 7 mensis Iulii anno 1987 in silva conifera* Sulęczyno *prope* Kościerzyna *(Polonia) collectum* (leg. S. Bałazy).

Insect body filled with rather polymorphic hyphal bodies, elongate or ameboid with vesiculate puffs and outgrowths, 40-150 µm long and 18-30 µm thick, giving rise to almost equally narrow, continuous hyphae 9.5-15 µm thick. The hyphae growing downwards from thoracical part after having perforated host's cuticle form compact, tissue-like, branched pseudorhizomorphs of rhizoids widened at ends into coarse holdfasts comprising a network of short, longitudinally lobate terminal branches. The hyphae perforating other parts of the host cuticle produce terminal, single on each, sporogenous cells, clavate or bottle-shaped, markedly distended comparing with the hypha diameter, 96-163 x 18-24 µm, separated by cross walls at the base; the empty conidiogenous cells are often flattened, wider in outline — up to about 32 µm. Primary conidia ovoid or pear-shaped, somewhat elongated into short neck at the base over the papillar convexity, so their dimensions are (39-)41-47 (-52) x 29.5-32-40(-44) µm with over-papillar neck 12-17 µm wide and 3-4 µm long, whereas the true papillar convexities are 4-7 µm high, often with small prick marked in the center. Secondary conidia of the first series indistinuishable, the subsequent series gradually smaller and smaller, often of more subglo-

Fig. 13. *Conidiobolus gustafssoni*: a — hyphal bodies, b — primary conidia, c — secondary sporophores, d — rhizoids (from *Ectobius lapponicus*, Forest Distr. Kościerzyna near Gdańsk).

bose appearence and proportionally narrower papillae. Conjugation and resting spores unknown. (Fig. 13).

Distribution and hosts. Poland: Central Pomerania, Cassubian Region near Kościerzyna (type locality); pathogen of *Ectobius lapponicus* De Geer; probably the same species was reported from the same host by Gustafsson (1965) from Sweden as *Entomophthora grylli* Fres.

Remarks. This species causes heavy epizootics in *E. lapponicus* population in clear Scots pine forests on the turn of June-July; observed specimens are invariably attached by stout fasciculate rhizoids to top parts of stems or pedicels of forest undergrowth plants, mostly the grass *Deschampsia flexuosa* (L.). Attempts at isolation of their strains to pure culture gave only once positive result, but the culture lost its vitality on broth agar enriched with egg yolk after first passage, so the fungus seems to belong to the group of highly specialized insect pathogens.

Etymology: To honour Professor Dr. Magnus Gustafsson, Swedish mycologist, who has probably first recorded this fungus.

(3.) *Conidiobolus bangalorensis* Srinivasan et Thirumalachar

Conidiobolus bangalorensis Srinivasan et Thirumalachar, Mycologia 59: 702. 1967.

Growth on PDA slow, colony diameter in 6 days at 21°C up to 25 mm. Hyphae thin, 2.8-4.5 µm wide, septate only at the bases of conidiophores. The latter are distinctly thicker, 100-150 x 13-16 µm. Primary conidia subglobose to pyriform, 20-25 x 13-16 µm, with conically tapering papillae 2-4 µm long and 3-6 µm wide at the base. Secondary conidia of the same type. Zygospores smooth, globose, 12-18 µm in diam., of the walls 1-1.5 µm thick.

Distribution and substrate. India, soil and litter.

(4.) *Conidiobolus eurymitus* Drechsler

Conidiobolus eurymitus Drechsler, Mycologia 57: 913. 1965.

Colony diameter on PDA in 5 days at 21°C about 50 mm. Vegetative hyphae 10-16 µm wide, of terminal segments at the margin often over 1 mm long. Conidiophores hypha-like 25-200 x 6-14 µm. Primary conidia globose to short ellipsoid, 15-54 x 13-45 µm, with papillae tapering and pointed, 2-8 µm long and 3-14 µm wide at the base. Secondary conidia of two types: the first similar to the primary and the second elongate with conically obtuse distal part, 24-41 x 10-17 µm, forcibly discharged. Zygospores smooth, globose to ellipsoid, 20-39 x 18-35 µm,

of the walls 1.5-4 µm thick, formed in axial alignment. Chlamydospores globose to ellipsoid 30-45 x 25-35 µm.

Distribution and substrate. North America, USA — Maryland, in plant detritus.

(5.) *Conidiobolus couchii* Srinivasan et Thirumalachar

Conidiobolus couchii Srinivasan et Thirumalachar, J. Elisha Mitchell Sci. Soc. 84: 211. 1968.

Colonies growing slowly on PDA, attaining in 5 days at 21°C about 15 mm in diam. Vegetative hyphae 3.5-6 µm thick produce many short branches of lobulate appearence. Conidiophores hypha-like, 30-50 x 4-7 µm. Primary conidia ovoid, 12.5-27 x 10-16 µm, with papillae 1.5-5 µm long and 3.5-8 µm wide at the base, tapered and more or less pointed. Secondary conidia of the common type and elongate 12-17 x 8-12 µm, forcibly discharged. Zygospores smooth, globose, 12-16 µm in diam., of the walls 1-1.5 µm thick.

Distribution and substrate. India, in organic detritus.

(6.) *Conidiobolus khandalensis* Srinivasan et Thirumalachar

Conidiobolus khandalensis Srinivasan et Thirumalachar, Mycologia 54: 692. 1962.

Growth on PDA very slow: colonies attain less than 10 mm in diam. in 3 days at 21°C. Vegetative hyphae 5-7 µm thick, soon becoming septate and disjoining into distended globose or ellipsoid segments, 20-60 x 15-30 µm. Conidiophores hypha-like, 10-30 x 4,5-8 µm. Primary conidia subglobose 17-21 x 14-18 µm, with tapering papillae 3-5 µm long and 4-7 µm wide. Zygospores smooth ellipsoid or subglobose, 21-30 x 17-22 µm, surrounded by the walls 1.5-3.5 µm thick, formed in axial alignment.

Distribution and substrate. India, organic detritus.

(7.) *Conidiobolus lamprauges* Drechsler

Conidiobolus lamprauges Drechsler, J. Wash. Acad. Sci. 43: 35. 1953.
Conidiobolus nanodes Drechsler, Am. J. Bot. 42: 439. 1955.

Colony compact and opaque of the diameter on PDA at 21°C in 3 days less then

30 mm. Vegetative hyphae in young parts of colonies moderately branched, 2-7 µm thick, divided by cross-walls into segments 25-200 µm long. In older zones hyphal segments produce often short outgrowths or branches giving them a lobulate appearence. Conidiophores hypha-like, 10-100 x 3.5-8 µm. Primary conidia globose to ovoid, 10-22 x 8-20 µm, with short, convex papillae 1-4 µm long and 2.5-7 µm wide. Zygospores smooth, globose, 7-18 µm in diam., of the walls 1-3 µm thick, formed in axial alignment.

Distribution and substrates. North America, organic detritus and flies infected with *Entomophthora muscae* s. l.

(8.) *Conidiobolus paulus* Drechsler

Conidiobolus paulus Drechsler, Bull. Torrey Bot. Club 84: 269. 1957.
Conidiobolus undulatus Drechsler, Bull. Torrey Bot. Club 84: 275. 1957. — *Conidiobolus parvus* Drechsler, Bull. Torrey Bot. Club. 89: 233. 1962.

Growth on PDA very slow; colonies diffuse, translucent, attain 4-10 mm in diam. at 21°C in 3 days. Vegetative hyphae rather thin, in marginal zones 1.5-8 µm wide, moderately branched. Conidiophores short, hypha-like or indistinctly widened in apical part, 15-40 x 3.5-8 µm. Primary conidia globose or ovoid 5-10 x 4-17 µm, with convex papillae, 1-5 µm long and 1.5-8 µm wide at the base, rather sharply protruding from the contour. Secondary conidia similar to the primary ones; according to Drechsler's drawing (1962 p. 235, figs. 2 G, H) some ability to from capillispores seems to occur in this species. Zygospores globose, 8-17 µm in diam., to short ellipsoid 10-25 x 8-20 µm, yellowish or uncoloured, borne laterally near apical union of two conjugating segments.

Distribution and substrates. North America, fallen leaves of a number of tree-species in early stages of decay.

(9.) *Conidiobolus adiaeretus* Drechsler

Conidiobolus adjaeretus Drechsler, J. Wash. Acad. Sci. 43: 42. 1953.

Growth on PDA moderately quick; colonies of the fuzzy appearence, attain less than 30 mm in diam. at 21°C in 9 days. Vegetative hyphae thin, 3-4.5 µm wide, richly branched and scarcely septate, usually only at protruding conidiophores. Conidiophores distinctly widened towards the tip, usually 4 or more times thicker than the vegetative hyphae. Primary conidia almost globose 15-46 x 13-45 µm, with short, obtusely rounded papillae 2-6 µm long and 5-17 µm wide at the base.

Chlamydospores globose to ellipsoid, 15-46 x 13-40 µm, produced in submerged mycelium at rather low temperatures (about 7°C).

Distribution and substrate. North America, organic detritus.

(10.) *Conidiobolus lachnodes* Drechsler

Conidiobolus lachnodes Drechsler, Am. J. Bot. 42: 442. 1955.
Conidiobolus nodosus Srinivasan et Thirumalachar, Mycologia 59: 705. 1967.
Conidiobolus terrestris Srinivasan et Thirumalachar, Mycopathol. Mycol. Appl. 35: 341. 1968.

Growth rate on PDA variable: one week old colonies attain at 21°C 18.5-50 mm in diam. Mycelium compact cottony-floccose or diffuse and translucent with scattered white patches. Hyphae filamentous, 2-8 µm thick, becoming septate, of elongate hyphal segments distending sometimes into almost globose cells. Conidiophores not differring from the hyphal branches. Primary conidia globose, 10-27 x 8-25 µm in diam., with small, convex papillae 1-4.7 µm long and 2-7 µm wide. Secondary conidia similar to the primary. Chlamydospores globose 11-25 µm in diam., formed by wall thickening of globose cells or terminally on procumbent hyphae.

Distribution and substrates. North America, Eastern States of the USA, and India, in terrestrial organic detritus and forest litter.

11. *Conidiobolus osmodes* Drechsler

Conidiobolus osmodes Drechsler, Am. J. Bot. 41: 571. 1954.

Growth on PDA quick; colony diameter attain 30 mm in 4 days at 21°C. Mycelium of distinctly radiating appearence; vegetative hyphae branched, 4-12 µm thick, becoming septate and divided onto noncontiguous segments with age. Conidiophores 30-60 x 4-12 µm. Primary conidia globose to ovoid, 25-37 x 22-30 µm, with broad, obtusely tapered papillae, 2-5 x 7-10 µm. Secondary conidia similar. Zygospores globose to ellipsoid, 13-37 µm in diam., surrounded by walls smooth or with weakly marked small ridges, 2-6.5 µm thick, arranged in axial alignment. Characteristic odor of benzene haxachloride is usually produced in cultures.

Distribution and substrates. North America, Australia, Israel, Europe, isolated from organic detritus and dead insects mostly *Phytonomus* spp. larvae and aphids in alfalfa fields.

Occurrence in Poland. Reported from several localities in North-Western Poland (Poznań, Szczecin, Piła) and surrounding areas and in the vicinity of Siedlce, mostly from aphids.

12. *Conidiobolus thromboides* Drechsler

Conidiobolus thromboides Drechsler, J. Wash. Acad. Sci. 43: 38. 1953.
Entomophthora virulenta Hall et Dunn, Hilgardia 27: 1957. — *Culicicola virulenta* (Hall et Dunn) Balazy, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 404. 1965.

Growth on PDA rapid: 4 day old colonies attain 40-60 mm in diam. at 21°C. Colony surface fuzzy on translucent background, toward the margin more and more diffuse. Vegetative hyphae moderately branched, consisting of elongate segments 50-200 x 6-13 µm, often noncontiguous, particularly in older zones. Conidiophores 35-150 x 10-15 µm. Primary conidia globose, 24-32 x 17.5-26.5 µm, containing in the center a number of large globules surrounded by finely granular protoplasm. Papillae relatively short, obtuse, merging smoothly with outline of conidia. Secondary conidia of the same type. Zygospores smooth, globose, 15-27 µm in diam., with the walls 1.5-3 µm thick. Conjugation mostly between segments of separate hyphae.

Distribution, substrates and hosts: North America, Asia, Australia, isolated from soil detritus, once from the fruitbody of the basidiomycete *Craterellus cornucopioides* (L. ex Fr.) Pers. and often from dead insects, mostly aphids. In Poland reported from the vicinity of Szczecin, Poznan and Siedlce, on aphids *Brevicoryne brassicae* (L.) and some species from *Solanaceae*, rarely on other hemipterous bugs or other insects.

Remarks: Entomopathogenic strains of this fungus misidentified as *Entomophthora taxteriana* (Fetch) Hall et Bell, a synonym of *Conidiobolus obscurus* (Hall et Dunn) Remaudière et Keller (see p. 74), were in seventies widely studied with the task to apply them in biological control of aphid (Humber et al. 1977).

13. *Conidiobolus stromoideus* Srinivasan et Thirumalachar

Conidiobolus stromoideus Srinivasan et Thirumalachar, Sydowia 16: 65. 1962.
Conidiobolus lichenicolus Srinivasan et Thirumalachar, Mycopathol. Mycol. Appl. 36: 344. 1968.

Growth on PDA moderately rapid: 4 day old colonies attain 15-40 mm at 21°C. Colonies diffuse and translucent with powdery surface. Hyphae branched, 7-10 µm thick, developing regularly spaced swollen areas and bearing more or less abundant, short diverticulae. Aerial branches occur especially with conidiophores. Conidiophores somewhat thickened 20-110 x 6.5-20 µm. Primary conidia globose to pyriform, 21-39 x 18-35 µm, with papillae 2-5 µm long and 4-8 µm wide, obtusely convex. Secondary conidia of the same type. Zygospores smooth, globose to ovoid 18-35.5 µm in diam., with walls 1-2 µm thick, formed in axial alignment.

Distribution and substrates. India, organic detritus and a fly infected with *Entomophthora muscae* s. l.

(14.) *Conidiobolus multivagus* Drechsler

Conidiobolus multivagus Drechsler, Am. J. Bot. 47. 373. 1960.

Mycelium on maize-meal agar inconspicuous; vegetative hyphae in colony center comprising of elongate or ellipsoid segments of rounded angles, about 30-120 or more µm long and 10-10 µm wide. Hyphae in marginal zone much thinner, 2-4 µm thick and rather equally narrow, of terminal segments even 200-350 µm long; poorly developed aerial hyphae are of similar dimensions. Conidiophores arise from hyphal segments of aerial part, phototropic, 20-75 µm long and 4-9 µm thick, slightly distended up to 7-12 µm in upper parts — about 10-15 µm below the tip. Primary conidia spherical, 10-25 µm in diam., with sharply convex, dome-shaped papillae, about 2-5 µm long and 4-8 µm wide in the base. Secondary conidia generally smaller, with distinctly less marked papillae. A number of rounded hyphal segments transform into some inactive, chlamydospore-like structures of the dimensions 20-70 x 1o-25 µm.

Distribution and substrate. USA, Florida, isolated from well-rotted plant detritus of *Casuarina equisetifolia* L.

15. *Conidiobolus obscurus* (Hall et Dunn) Remaudière et Keller

Conidiobolus obscurus (Hall et Dunn) Remaudière et Keller, Mycotaxon 11: 330. 1980; — *Entomophthora obscura* Hall et Dunn, Hilgardia 27: 162. 1957; — *Entomophaga obscura* (Hall et Dunn) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 404. 1964.

Empusa thaxteriana Petch, Trans. Brit. Mycol. Soc. 21: 34. 1937. (nom. inval.); — *Entomophthora thaxteriana* (Petch) Hall et Bell, J. Insect Pathol. 5: 186. 1963; — *Entomophaga thaxteriana* (Petch) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 404. 1964; — *Empusa planchoniana* sensu Thaxter, Mem. Boston Soc. Nat. Hist. 4: 165. 1888 (nec *Entomophthora planchoniana* Cornu, Bull. Soc. Bot. France 20: 189-190. 1873); — *Entomophthora ignobilis* Hall et Dunn, Hilgardia 27: 162. 1957.

Mycelium filling the host body cavity filamentous and branched, easily fragmented into elongate, ovoid or somewhat polymorphic hyphal bodies about 50 to several hundred µm long and 8-18 µm wide, often wich irregularly distributed swellings and outgrowths. Hyphae grow also into legs and antennae, often forming there single hyphal bodies. Conidiophores grow usually in small groups, scattered all over the host body, often in juctions of legs and antennae. Conidiogenous cells

slightly clavate or only indistinctly widened in subapical parts, about 100 µm long and 13-20 µm thick in the widest part. Primary conidia almost globose, 29-34 µm in diam., occasionally single may be greater, with abruptly protruding obtusely convex papillae 6-8.5 µm long and 12-16 µm wide in the base. In some strains the primary conidia of less sharply protruding papillae with small spine marked in the center of their convexity may be produced. The content of the central part of the conidia is globular of relatively big diameter of particular globules — about 6-7 µm. Secondary conidia of the same type. Resting spores globose, rarely subglobose, 35-41 µm in diam., surrounded by walls 2.5-4 µm thick, with roughly granular content when young and vacuolate after ripening, reported as zygo- or azygospores.

Distribution and hosts. The world over, common pathogen of different aphid species, also isolated from soil.

Occurrence in Poland. Szczecin and surrounding, Poznań, Wielkopolski National Park, vicinity of Kościerzyna, Turew near Leszno, Konin, Siedlce — suburban area in the Liwiec River Valley, Białowieża Forest, Lublin and surrounding; reported from the following hosts: *Acyrtosiphon pisum* (Harris), *Aphis fabae* Scopoli, *Brevicoryne brassicae* (L.), *Capitophorus similis* v. d. Goot, *Impatientinum asiaticum* (Nevsky), *Macrosiphum prenanthidis* Börner, *Microlophium evansi* (Theob.), *Sitobion avenae* (Fabr.) *Uroleucon cirsii* (L.), *U. tussilaginis* (Walker).

Remarks. Particular strains of this fungus grow generally well on common media, especially those enriched with egg yolk, some products of soya bean, proteins and fatty acids. However, the development, especially growth rate, conidiation and resting spore formation, as well as colony appearence on PDA vary considerably so it is at present dificult to introduce them unequivocally into King's (1976 b) key arrangement. Moreover, a considerable variation of aforesaid parameters has been stated in monosporic cultures of the same strains (E. G. Voronina — pers. comm.). The fungus has been widely studies as potential aphid control agent, although a part of older data concerns also the species *C. thromboides* (see, p. 72) as a result of misidentification (Humber et al. 1977).

16. *Conidiobolus utriculosus* Brefeld

Conidiobolus utriculosus Brefeld, Unters. Ges. Mycol. 6: 37. 1884.

Vegetative mycelium consisted of sparsely septate and moderately branched hyphae 7.5-25 µm thick, with abundant lobate outgrowths. Conidiophores 135-270 µm long distinctly widening towards apex, 11-25 µm thick. Primary conidia pyriform or ovoid 37.5-51 x 25-35 µm, with strongly convex papillae 4.5-8.5 µm long and 9.5-16 µm wide at the base. Secondary conidia similar, smaller. Zygospores globose to ellipsoid, 40-73 x 33-60 µm, with rough epispore, hyaline or bright yellow; gametangia obvious or indistinct.

Distribution and substrate. Central Europe (vicinity of Wrocław), from fruit bodies of *Exidia* sp. and *Hirneola* sp. (*Tremellales*), reported by Brefeld (1884) as common; known only from the type locality.

Remarks. Srinivasan and Thirumalachar (1967) considered *C. minor* Brefeld (1884: 68) to be the synonym of *C. utriculosus*. However, Brefeld was aware of the variability range of the secondary conidia of *C. utriculosus*, so — taking into account also conspicuous differences in shape and size — the reason to establish such a synonymy is pretty weak, having rather character of unverifiable supposition. One can expect to solve this problem after rediscovery and re-examination of associated entomophthoralean fungi from the tremellaceous fruit bodies.

17. *Conidiobolus chlapowskii* Bałazy, Wiśniewski et Kaczmarek

Conidiobolus chlapowskii Bałazy, Wiśniewski et Kaczmarek, Bull. Acad. Pol. Sci. 35 (7-9): 201-204. 1987.

Hyphal bodies filling host's body cavity of variable shapes — ovoid, ameboid, clavate or elongate, 25-101 x 10-23.5 µm, often with thinner irregular outgrowths 3-6.5 µm thick and of variable length; superficial filamentous mycelium of the hyphae 9-16 µm thick develops on a host. Conidiophores 20-150 x 5-15.6 µm hypha-like, not thickened in subapical part. Primary conidia globose (34-) 36.5-41 (-45) µm in diam., with conically tapered papillae 7-14 µm long and 8.5-15.5 µm wide at the base, of acutate ends. Secondary conidia globose (18.5-) 26-33.5(-37.5) µm in diam. with papillae usually convex and apically obtuse, 3-7 µm long and 7-12 µm wide, formed on secondary sporophores 6-65 x 6-8.5 µm. The conidia transform easily into spherical durable forms (loricoconidia) by thickening of their walls to 1.5-3 µm and loss of papillae; their diameter is (25-)32-41(-46) µm. Nuclei 1-1.6 µm in diam., weakly staining with acetocarmine.

Distribution and host. Poland, Turew near Poznań, in *Pergamasus* sp. (*Acariņa*). Known only from the type locality. Attempts at culture isolation failed.

Subgenus *Delacroixia* (Saccardo et Sydow) Tyrrell et MacLeod

Delacroixia Saccardo et Sydow, Syll. Fung. 14: 457. 1899 (as a generic name); — *Conidiobolus* subg. *Delacroixia* Tyrrell et MacLeod, J. Invertebr. Pathol. 20: 11-13. 1972.

The main feature of species belonging to this subgenus is the ability to from so called microconidia, produced on short tubular sporophores growing in considerable numbers — from several to about twenty — from one primary or secondary conidium and forcibly discharged by papilla eversion. Conidiophores not differentiated from the aerial hyphae or slightly thicker, unbranched or exeptionally furcate. Primary conidia spherical or ovoid pear-shaped, papillate, of variable size in

the same strains, often with similar variation intervals in different species. Saprophytes or facultative parasites of animals and man, also isolated from fruit bodies of higher fungi.

Type species: *Conidiobolus coronatus* (C o s t a n t i n) B a t k o.

The species identification is based on the morphological features of the mycelium in artificial cultures (K i n g 1976, 1977), considering some physiological properties. The simplified key for identification presented below has been complied on the basis of King's monograph and other accessible materials. This group requires further taxonomical investigations and supplementary morphological and physiological characteristics for particular species. In few cases, when the microconidia are hardly produced or have not been stated in some strains, the species have also been considered in the key for species of the subgenus *Conidiobolus*.

Key to species

1. Entomopathogenic species producing rhizoids on infected insects, with insufficient characteristics in artificial cultures; on scale insects . . . . . *C. pseudococci*, p. 82
1*. Species considered to be mainly saprophytic or weakly zoopathogenic, well characterized in artificial cultures 2
2. Mycelium hyphal, branched; hyphae at least in mariginal zones of colony continuous; the hyphae or their segments more or less cylindric, evenly thick, several dozen to several hundred μm long, only in central parts of older cultures septation may be stronger, sometimes with distinguished globose or elongate chlamydospores 3
2*. Mycelium even in the youngest stages of growth irregularly segmented, forming polymorphic or subglobose hyphal bodies; colonies small, untransparent, yeast-like, light-brown in color; conidiophores not thickened in upper parts; papillae of the primary conidia strongly sticking, obtuse; zygospores globose 20-36 μm diam. with walls 0.5-1.5 μm thick . . . . . *C. mycophilus*, p. 81
3. Grown on PDA slow, colonies do not exceed 25 mm diam. in 3 days at the temperature 21°C 8
3*. Growth on PDA faster, colonies attaining over 30 μm diam. in 3 days at the temperature 21°C, if the colonies are smaller — globose chlamydospores appear in the mycelium 4
4. Chlamydospores present in submerged mycelium, particularly in older zones of colonies; papillae of primary conidia pointed 5
4*. Chlamydospores absent 6

5. Colonies cottony on transparent background, consisting of long, segmented hyphae 2-20 µm thick; chlamydospores subglobose or barrel-shaped, 15-50 x 8-48 µm, in some strains absent; sizes of the primary conidia strongly differentiated 8-50 x 6,5-45 µm; zygospores unknown . . . . . *C. firmipilleus*, p. 79

5*. Colony surface powdery; hyphae short-segmented, 7-10 µm diam.; chlamydospores globose, occur in older zones of colonies; conidia subglobose or pyriform, 26-38 x 23-34 µm; zygospores globose 7-20 µm in diam. or elongate even up to 35 µm long . . . . . *C. humicolus*, p. 80

6. Colonies at first white then light brown with whitish powdery surface; conidiophores slightly distended in central part 30-21 x 9.5-25 µm; villose resting spores usually occurring; zygospores unknown . . . . . *C. coronatus*, p. 78

6*. Colonies velvety-lanose without brown colour; villose resting spores lacking 7

7. Conidiophores of the same thickness as vegetative hyphae or not markedly thickened; primary conidia pyriform or broadly ellipsoid, 25-54 x 30-50 µm, with papillae, obtuse, rather broad and strongly sticking, 8-23 x 6-15 µm; antheridium-like distentions do not form at the conjugation . . . . . *C. macrosporus*, p. 80

7*. Conidiophores distinctly thickened as compared with vegetative hyphae, if slightly widened then papillae of the primary conidia pointed at tip; antheridium-like distentions at the conjugation occur; primary conidia globose with smaller papillae . . . . . *C. megalotocus*, p. 81

8. Primary conidia subglobose 14-29 x 12-25 µm with abruptly protruding, tapered papillae, 4-7.5 x 2-6 µm; conidiophores 20-30 x 5-12 µm; zygospores unknown . . . . . *C. polytocus*, p. 82

8*. Primary conidia globose to pyriform, generally greater, up to about 40 µm and with greater range of variability; zygospores present 9

9. Colonies compact, opaque, with dense aerial mycelium; hyphal segments in older colony parts 6-25 µm thick; primary conidia 12-42 x 11-37 µm with relatively long, tapered papillae 2-12 x 2-9 µm; microconidia subglobose to ellipsoid, 8-16 x 5,5-11 µm; conidiophores 20-130 µm long . . . . . *C. incongruus*, p. 79

9*. Colonies not compact, hyphae 5-8.5 µm thick; primary conidia 20.5-36 x 10-31 µm with shorter papillae, up to about 7.5 µm long; microconidia greater, subglobose to ovoid, 12.5-17 x 10.5-15.5 µm; conidiophores short 15-50 x 6-10 µm . . . . . *C. brefeldianus*, p. 78

(18). *Conidiobolus brefeldianus* Couch

Conidobolus brefeldianus Couch, Am. J. Bot. 26: 119. 1939.

Colony diameter on PDA in 3 days at 21°C about 20 mm. Hyphae of rather uniform diameter 5-8 µm, not lobed or compact. Conidiophores 15-50 x 6-10 µm slightly widened in subapical part. Primary conidia subglobose 20.5 x 36 x 10-31 µm with obtuse papillae 4-7.5 x 4.5-9 µm. Microconidia subglobose to ovoid 12.5-17 x 10.5-15.5 µm, borne on pedicles 4-6 x 2.5-5 µm. Zygospores globose, 18-33 µm in diam., surrounded with the wall 1.5-5 µm thick of smooth surface, formed in axial alignment with one or both conjugating segments. Conjugation anisogamous that one conjugating segment produce an antheridium-like distention.

Distribution and substrate. North America, USA, isolated as a contamination from a fruit body of *Septobasidium apiculatum* Couch.

19. *Conidiobolus coronatus* (Costantin) Batko

Conidiobolus coronatus (Costantin) Batko, Entomophaga, Mem. Hors., Ser. 2: 129. 1964; — *Boudierella coronata* Costantin, Bull. Soc. Mycol. Fr. 13: 40. 1897; — *Delacroixia coronata* (Costantin) Sacc. et Sydow, Syll. Fung. 14: 457. 1899; — *Entomophthora coronata* (Costantin) Kevorkian, J. Agaric. Puerto Rico 21: 198. 1937; — *Conidiobolus coronatus* (Costantin) Srinivasan et Thirumalachar, Mycopathol. Mycol. Appl. 24: 296. 1964; — *Conidiobolus* subg. *Delacroixia coronata* (Costantin) Tyrrell et MacLeod, J. Invert. Pathol. 20: 12. 1972.
Conidiobolus villosus Martin, Bot. Gaz. 80: 311-318. 1925.

Growth quick, colony diameter on PDA in 3 days at 21°C 40-50 mm. Surface fuzzy, often pale brownish with age of powdery appearance. Vegetative hyphae 4.5-17 µm thick, in older parts of colony separated by septation into moncontiguous, often thickened segments, Conidiophores hypha-like, varying in length 30-210 x 9.5-25 µm, slightly thickened. Primary conidia varying in the range (10.5-) 14.5-38.5 (-67) x 17-48.5 µm, with abruptly protruding papillae 3-14 x 5-13 µm, of the sides indistinctly narrowed toward obtuse apex. Microconidia most frequently 15.5-20 x (7.5-) 9.5-14 (-20) µm, borne on pedicels 4-9.5 x 3-4.5 µm. Globose conidia may transform into villose resting spores by direct thickening of their walls (loricoconidia), especially under dry conditions, but the villose appendages may not appear.

Distribution, substrates and hosts. Europe, Asia, North and South America, detritus, living plants, different dead arthropods and occasionally in cases of mycoses of warm blooded animals and man (Bridges et al. 1962; MacLeod & Müller-Kögler 1973; Domsch et al. 1980). Reported from many localities in Poland: Pomerania, vicinity of Poznań, Warsaw and surrounding, Białowieża Forest, vicinity of Zielona Góra. Identified hosts in Poland:

Acyrtosiphon pisum (Harris), *Aphis fabae* Scop., *Brevicoryne brassicae* (L.), some species of aphids on potatoes (Bałazy et al. 1990). Experimentally infected were also a mite of the family *Tyroglyphidae*, *Thermobia domestica* (Packard) (*Insecta: Apterygota*, Batko 1974a) and many other insect species. Also isolated as contaminations from flies infected with *Zoophthora* subg. *Erynia ovispora* in Turew near Poznań.

Remarks. Some authors, (e.g. MacLeod and Müller-Kögler 1973) have reservations as concerns the correctness of this species identification in some cases. Batko (1974) considered it possible that a grater number of closely related species may hide under this name. The ranges of its variability and possible diversity or intraspecific differentiation requires further detailed studies.

(20). *Conidiobolus firmipilleus* Drechsler

Conidiobolus firmipilleus Drechsler, Am. J. Bot. 40: 104. 1953.
Conidiobolus chlamydosporus Drechsler, Am. J. Bot. 42: 799. 1955.

Colony diameter on PDA in 3 days at 21°C about 40 µm. Aerial mycelium ligtly fuzzy over the entire surface against a translucent background. Vegetative hyphae filamentous with the terminal segments near margins 100-500 x 2-20 µm, in older parts moncontiguous, 20-250 µm long and slightly distended. Conidiophores hypha-like of variable length, 20-500 x 3-16 µm or even longer. A portion of residual protoplasm leaves often in the conidiophore after the conidium delimination forming a vacuolate living cell. Primary conidia subspherical, 8-50 x 6.5-45 µm, with minute to broadly conical papillae 1-8 x 1.5-13 µm, often pointed at ends. Microconidia 10-16 x 8-11 µm, borne on pedicels 3-7 x 1.5-2 µm, rather hardly produced, in some strains unobserved. Chlamydospores subspherical or barrel-shaped, 15-50 x 8-48 µm, usually produced, in some strains abundant but sometimes lacking.

Distribution and substrate. North America, soil and litter.

(21). *Conidiobolus incongruus* Drechsler

Conidiobolus incongruus Drechsler, Am. J. Bot. 47: 370. 1960.
Conidiobolus gonimodes Drechsler, Mycologia 53: 291. 1961.

Colonies on PDA in 3 days at 21°C about 20 mm in diam., compact and opaque, with aerial mycelium; numerous small colonies developed around the original colony. Vegetative hyphae filamentous and branched near the margins, with particular segments 40-400 x 5-9 µm, becoming soon septate and secondarily divided into noncontiguous hyphal bodies 6-25 µm thick. Conidiophores 20-130 x 5-12 µm. Primary conidia globose to ellipsoid, 12-42 x 11-37 µm, with more or

less tapering and pointed papillae 2-9 x 2-12 µm. Microconidia globose to ellipsoid, straight or bent, 8-16 x 5-11 µm, borne on short pedicels 2-4 x 2-3 µm, readily produced on water agar. Zygospores globose or somewhat elongate, 15-30 x 11-25 µm, of walls smooth, 1-3 µm thick, produced in axial alignment with conjugating segments. Conjugation usually between adjacent cells of the same hypha.

Distribution and substrates. North America, soil and litter, isolated also in a case of the mycosis of an infant (King & Jong 1976).

(22). *Conidiobolus humicolus* Srinivasan et Thirumalachar

Conidiobolus humicolus Srinivasan et Thirumalachar, Sydowia 15: 240. 1961.

Growth on PDA rather slow, colony diameter attains about 35 mm in 7 days at 21°C. Colonies translucent when young, becoming powdery in appearence at the time of conidiation. Vegetative hyphae branched, 7-10 µm wide, with particular segments in marginal zone about 50-350 µm long. Conidiophores hypha-like 40-350 x 4-10 µm. Primary conidia globose to pear-shaped, 26-38 x 23-34 µm, with shortly protruding, pointed papillae 3-4 µm. Microconidia 9-12 x 7-9.5 µm borne on short and thin sterigmata 2.5-4.5 x 1.5-3 µm. Zygospores usually globose 14-25 µm in diam., sometimes elongate or irregular, 7-20 x up to 30 µm. Globose chlamydospores 15-25 µm in diam. appear in older parts of cultures.

Distribution and substrate. India, organic detritus.

23. *Conidiobolus macrosporus* Srinivasan et Thirumalachar

Conidiobolus macrosporus Srinivasan et Thirumalachar, Mycologia 59: 702. 1967.
Conidiobolus megalotocus var. *indicus* Srinivasan et Thirumalachar, Sydowia, 16: 61. 1962.

Growth on PDA moderately quick, colony diameter in 4 days at 21°C attains 35 mm. Colonies translucent, radiately growing and aquirring a powdery surface in the older zones. Vegetative hyphae 8-15 µm thick, soon septate and segmented. Conidiophores hypha-like or very slightly widened towards apex, 30-200 x 8-15 µm. Primary conidia globose to pyriform, 25-54 x 30-50 µm with long, abruptly protruding papillae 6-15 x 8-23 µm, sligtly tapered and usually rounded, but sometimes pointed at ends. Microconidia 11-21 x 10-17.5 µm, borne on relatively long sterigmata 5-15 x 2.5-5 µm, formed on water agar at 37°C. Zygospores — if pres-

ent — globose, smooth, 26-40 µm in diam., surrounded by walls 2-3 µm thick, formed in axial alignment with conjugating segments.

Distribution and substrate. India, organic detritus. A fungus of quite identical morphology except production of microcomidia appeared abundantly in a laboratory rearing of subcortical detritus (Norway spruce infested by bark beetles from forest distr. Jarocin), on small flies of the family *Sciaridae*.

(24). *Conidiobolus megalotocus* Drechsler

Conidiobolus megalotocus Drechsler, Am. J. Bot. 43: 778. 1956.
Conidiobolus eurypus Drechsler, Sydowia 9: 189. 1957.
Conidiobolus polyspermus Drechsler, Mycologia 53: 279. 1961.

Colonies on PDA in 3 days at 21°C attain the diameter 28-45 mm; their surface is floccose of sharply delimited borders. Mycelium not compact; vegetative hyphae at the margins 4-6 µm thick, divided into segments 15 µm to over 1 mm long, becoming distended to 11-15 µm and shortened with age. Conidiophores usually unbranched, 20-280 x 7-18 µm, seldom with one or two branches. Primary conidia almost globose,, 12-55 x 10-48 µm, with papillae abruptly protruding, conical and pointed at tip or obtusely convex, smoothly coming into the conidium contour. Microconidia 13-23 x 9-17 µm, borne on sterigmata 15-16 x 1.5-2.5 µm, readily produced in some strains, not produced at all in the others. Zygospores, if present, subglobose or globose, 15-48 x 14-45 µm, of the walls 1-8 µm thick, formed in axial alignment with one or both conjugating segments; the latter form often antheridium-like distention during conjugation.

Distribution and substrates. North America; soil detritus.

(25). *Conidiobolus mycophilus* Srinivasan et Thirumalachar

Conidiobolus mycophilus Srinivasan et Thirumalachar, Sydowia, 19: 86. 1965.
Conidioblus mycophagus Srinivasan et Thirumalachar, Sydowia. 19: 88. 1985

Growth on PDA at 21°C very slow, colonies of the diam. 7-14 mm in 2 days. Colonies opaque, light brown and yeastly or chalky in central part, becoming gradually translucent towards the margin, with many small colonies scattered around the periphery. Hyphal segments soon delimited as short ameboid or polymorphically branched hyphal bodies, 6-15 µm wide. Conidiophores 30-150 x 3.5-10 µm, hypha-like, neither distended nor branched. Primary conidia subglobose, 25-40 x 20-33 µm, with rather abruptly protruding papillae obtusely rounded at tips, 3-10

µm long and 6-14 µm wide at the base. Microconidia globose to pyriform, 14-18 x 6-12 µm. Zygospores subglobose and globose 20-36 µm in diam., walls 0.5-1.5 µm thick.

Distribution and substrates. India, old fruit bodies of *Basidiomycetes*.

(26). *Conidiobolus polytocus* Drechsler

Conidiobolus polytocus Drechsler, Am. J. Bot. 42: 793. 1955.

Growth on PDA moderate, colony diameter attains 25 mm in 3 days at 21°C. Colonies translucent with powdery surface. Vegetative hyphae at the margin 2-9 µm wide, hyphal segments in older zones 25-200 µm long, often monocontiguous. Conidiophores short, hypha-like, unbranched 20-30 x 5-12 µm. Primary conidia subspherical, 14-29 x 12-25 µm, with abruptly protruding and conically tapered papillae, 2-6 µm long and 4-7.5 µm wide at the base. Microconidia ovoid to almost spherical, 7-15 x 6-11 µm, readily produced on short sterigmata 2-5.5 x 1.5-2 µm.

Distribution and substrate. North America, USA – Illinois, Indiana, Wisconsin, in plant detritus.

(27). *Conidiobolus pseudococci* (Speare) Tyrrell et MacLeod

Entomophthora pseudococci Speare, Rep. Exp. Sta. Hawaiian Sugar Planters, Assoc., Pathol. Physiol. Ser., Bull. 12: 26. 1912; — *Conidiobolus* subg. *Delacroixia pseudococcus* (Speare) Tyrrell et MacLeod, J. Invertebr. Pathol. 20: 12. 1972.

Colony growth on different substrates, including potato and some agars based on potato decoction, reported by Speare (1912) as generally slow, but particular measurements were not given. The hyphae at first richly branched, soon dividing into not contiguous and distinctly separated hyphal segments, abundant in older parts of colonies and producing sucessivelly polymorphic hyphal bodies often twisted. Conidiophores unbranched or quite exceptionally with one subapical branch, 75-160 x 13-16 µm, very slightly distended in the terminal part. Primary conidia globose of the diameter 20-25 µm, with abruptly protruding, stout papilla, 7-11.5 µm long and of the same width at the base, with almost cylindrical or only slightly convergent basal part and broadly conical, tapered end. Successive secondary conidia of the later series attain barely about 5 µm in diam. Microconidia globose about 7 µm in diam., borne on pedicels about 3-10 x 2-3 µm. Zygospores axially arranged, globose, 20-27 µm in diam., formed in recepting gametangium as result of anisogametangiogamy, and surrounded by about 5-6 µm thick,

two-layered wall, from which the external, thinner of the smooth surface, derive from the thickened gametangium wall. Conjugation takes place usually between two adjacent cells or two hyphal bodies modified before by antheridium-like distention in one of them. Few rhizoids present in the form of thin fascicles comprising 3-4 hyphae, with short branches at ends.

Distribution and host. Hawaii, Honolulu, on *Pseudococcus calceolariae* Maskell, though Speare (1912: 9) had some doubt concerning the correctness of host's identification. The fungus known only from the type locality.

Remarks. The above description has been compiled after Speare's (1912) original diagnosis, observations and drawings, considering the papers of Tyrrell and MacLeod (1972) and King (1977).

Subgenus *Capillidium* Ben-Ze' ev et Kenneth

Conidiobolus subg. *Capillidium* Ben-Ze' ev et Kenneth, Mycotaxon 14: 431. 1982.

The base for the separation of this subgenus is the ability to produce the secondary conidia of the capillispore type besides the typical secondary ballospores of the type I according to Ben-Ze' ev and Kenneth (1982). The capillary sporophores are relatively long and distinct, usually 30-180 µm long, but in *C. rhysosporus* even 100-250 µm long and 1.5-4.5 µm thick at the base. Conidiophores of relatively differentiated lengths, hypha-like, only in *C. rhysosporus* markedly widening toward the apex. Characteristics of the mycelium and colonies as in the generic description.

Type species: *Conidiobolus heterosporus* Drechsler.

According to Drechsler's (1962: 238-239, fig. 2 G, H) note and drawings the species *Conidiobolus parvus* Drechsler, considered by King (1976: 1293) to be conspecific with *C. paulus* Drechsler included into the subgenus *Conidiobolus*, seems to show some rudimental ability to produce capillispores.

Key to species

1. Growth on PDA relatively slow: 3 day old colonies at 21°C about 10-15 mm in diam; zygospores not observed 2
1*. Colony diameter on PDA in 3 days at 21°C exceeds 20 mm; zygospores usually present 3
2. Mycelium compact with numerous lobate or dilated branches or outgrowths on the hyphae; primary conidia globose 21-26 x 20-24 µm, with small, tapering papillae of rounded tip . . . . . *C. lobatus*, p. 84

2*. Mycelium without lobate branches; primary conidia subglobose or turbinate, 9-32 x 6-25 µm, with relatively long tapered papillae . . . . . *C. pumilus*, p. 85

3. Conidiophores markedly widening towards apex; primary conidia globose, 22-36 x 18-30 µm with broadly rounded papillae; zygospores 13-31 µm diam. with 1-2.5 µm thick, yellowish wall . *C. rhysosporus*, p. 85

3*. Conidiophores not widening markedly towards apex; primary conidia globose, 10-35 x 9-30 µm, with tapered papillae rounded at tip; zygospores globose, elongate or irregular, 7-8 µm in diam., with hyaline or pale yellowish wall 0.8-2 µm thick, sometimes lacking . . . . . *C. heterosporus*, p. 84

(28.) *Conidiobolus heterosporus* Drechsler

Conidiobolus heterosporus Drechsler, Am. J. Bot. 40: 107. 1953.
Conidiobolus rugosus Drechsler, Am. J. Bot. 42: 437. 1955.

Colony growth on PDA moderate to quick; colonies inconspicuous until conidiation, attain 20-40 mm in diam. in 3 days at 21°C, often darkening with age, without or with very scarce aerial mycelium. Vegetative hyphae filamentous and branched, of particular segments near the margin 30-250 µm long and 5-10 µm thick, with age transforming into noncontiguous hyphal bodies, somewhat distended and rounded at ends. Conidiophores hypha-like, not distended, of variable size, 10-100 x 5-13 µm. Primary conidia almost globose, 10-35 x 9-30 µm, with papillae obtuse, fluently protruding from the conidium outlines, 1-6 x 3.5-12 µm. Secondary conidia similar. Capilliconidia elongate, 15.5 x 31.5 x 7-20 µm, borne on 30-100 µm long capillary sporophores which are about 4 µm thick and often bi- or trifurcate at the base, narrowing upwards to less than 2 µm. Zygospores — if present — globose or somewhat elongate or irregular, 7-18 µm in diam., surrounded with hyaline or pale yellow wall 0.8-2 µm thick of rough surface, formed in axial alignment with conjugating segments.

Distribution and substrate. North America, South-Eastern Asia, in organic detritus.

(29.) *Conidiobolus lobatus* Srinivasan et Thirumalachar

Conidiobolus lobatus Srinivasan et Thirumalachar, J. Elisha Mitchell. Sci. Soc. 84: 212. 1968.

Growth on PDA very slow; colony diam. in 3 days at 21°C less than 10 mm. Older colonies opaque, dull white, often slightly darkening, without aerial mycelium. Hyphae 6-8 µm wide with numerous lobate or dilatate branches and outgrowths. Conidiophores 40-60 x 5.5-9.5 µm. Primary conidia globose, 21-26 x 20-24 µm, with small tapering papillae of obtuse ends, 1-2 x 2-4 µm, merging smoothly with outline of conidia. Secondary ballospores similar to the primary. Capilliconidia elongate and ellipsoid 18-25 x 8.5-10 µm; capillary sporophores 30-180 µm long, 2-3 µm thick at the base. Zygospores unknown.

Distribution and substrate. India, plant detritus.

(30). *Conidiobolus rhysosporus* Drechsler

Conidiobolus rhysosporus Drechsler, Am. J. Bot. 41: 567. 1954.

Growth on PDA moderate; colonies attain about 30 mm of diam. in 3 days at 21°C. Aerial mycelium none or scarce. Vegetative hyphae filamentous and branched of relatively long segments, at the colony margins 300-750 x 4-11 µm, in central parts 50-300 µm long, noncontiguous. Conidiophores widened near the apex, 40-100 x 7-12 µm. Primary conidia subglobose, 22-36 x 18-30 µm, with obtuse, smoothly merging papillae, 3-7 x 7-12 µm wide. Secondary conidia similar, gradually smaller. Capilliconidia ellipsoid, 12-32 x 6.5-16 µm. Capillary sporophores 100-250 µm long, 2-4.5 µm wide at the base. Zygospores usually globose 13-31 µm in diam., with yellowish wall 1-2.5 µm thick, of usually rough but sometimes smooth surface, formed in axial alignment with conjugating hyphal segments. Subspherical chlamydospores 8-15 x 5-12 µm appear in old cultures.

Distribution and substrate. North America, in forest litter.

(31). *Conidiobolus pumilus* Drechsler

Conidiobolus pumilus Drechsler, J. Wash. Acad. Sci. 45: 115. 1955.
Conidiobolus globuliferus Drechsler, Am. J. Bot. 43: 783. 1956. — *Conidiobolus denaeosporus* Drechsler, J. Wash. Acad. Sci. 47: 309. 1957. — *Conidiobolus inordinatus* Drechsler, J. Wash. Acad. Sci. 47: 312. 1957.

Growth on PDA rather slow, colony diameter 12-17.5 mm in 3 days at 21°C, with abundant or at least conspicuous aerial mycelium. Hyphae in young colonies filamentous, 2-9 µm thick, becoming septate and in older parts divided into noncontiguous segments 20-75 µm long. Conidiophores hypha-like, not distended, 15-60 x

3.5-11 µm. Primary conidia subglobose to turbinate, 9-32 x 6-25 µm, with papillae tapering, 1-7 x 3-13 µm, merging fluently with the conidium outline. Capilliconidia elongate 9-22 x 5-12 µm. Capillary sporophores 35-100 µm long, 1.5-3 µm thick at the base. Chlamydospores — if present — formed in submerged and procumbent hypahe, usually intercalar, subglobose, ellipsoid or of irregular shapes, 15-42 x 12-28 µm.

Distribution and substrate. North America, USA, in decaying plant material.

Genus *Macrobiotophthora* Reukauf emend. Tucker

Macrobiotophthora Reukauf, Centralbl, Bakt. Parasit. Infektionskrkh. Abt. 1, 63: 390. 1912; – Tucker, Mycotaxon 13: 498. 1981.

Vegetative mycelium develops within a host giving rise the external hyphae and shorter, unbranched, hypha-like conidiophores, slightly or not at all distended in subapical parts. Primary conidia unitunicate, oligokaryotic, obovate or with slightly convex, almost truncate base, discharged by papilla eversion. Secondary conidia passively detached. Zygospores irregularly globose or obtuse multiangular in outline, with obtusely warted surface, produced in result of scalariform or lateral conjugation of neighbouring hyphae or hyphal bodies. Parasites of *Tadigrada* and *Nematoda*.

Type species: *Macrobiotophthora vimariensis* Reukauf.

Tucker (1981) suggested to include this genus into the family of *Entomophthoraceae*. Recently, however, Humber (1989) considering new Tucker's data on the karyology of *Macrobiotophthora* species transferred it into *Ancylistaceae*. Because these data are not yet generally known, I consider it advisable to include this genus into the key for the family *Entomophthoraceae*, too (see p. 94). Tucker (1981) supposes that so-called *Conidiobolus*-like fungi reported from nematodes by Castner (1968) and Amin and Webster (1980) may also be representatives of the genus *Macrobiotophthora*.

Key to species

1. Vegetative thallus consisting of hyphal bodies; resting spores unknown; parasitic in tardigrades . . . . . *M. vimariensis*, p. 87
1*. Vegetative thallus consisting of non-septate hyphae; resting spores dodecahedral, about 20 µm diam.; parasitic in nematodes . . . . . *M. vermicola*, p. 87

(1). *Macrobiotophthora vimariensis* Reukauf

Macrobiotophthora vimariensis Reukauf, Centralbl. Bakt. Parasit. Infektionskrkh., Abt. 1, 65: 390. 1912.

Vegetative thallus develops in host's body cavity as hyphal bodies giving rise to external, short conidiophores 4-5 µm thick. Primary conidia oligokaryotic, 18-21.5 x 11.5 µm, obovoid with truncate base, forcibly discharged by papilla eversion. Secondary conidia probably of the same type. Conjugation and resting spores unobserved.

Distribution and hosts. Central Europe, Germany, parasite of the tarigrade *Hypsibius dujardini* (Doyere) in moist habitat.

(2). *Macrobiotophthora vermicola* (McCulloch) Tucker

Macrobiotophthora vermicola (McCulloch) Tucker, Mycotaxon 13: 499-501 — *Entomophthora vermicola* McCulloch, Trans. Brit. Mycol. Soc. 68. 173. 1977.

Infected nematode body filled with non-septate hyphae 5-7 µm in diam., developing thinner, flexuous, continuous hyphae penetrating the cuticle and growing externally at the length of (40-) 110-160 µm. Conidiophores thicker, 27-50 x 6-8 µm. Primary conidia obovoid, 16-22 x 9-14 µm, seldom greater, up to 30 x 16 µm, oligokaryotic, adhesive to nematode body. Secondary conidia medialy constricted, non-papillate, 14.4-15.5 x 9-13.3 µm, narrowing towards a basal neck to 7.4-8.9 µm, passively detached from the secondary sporophores 17-20 x 2.5-4.5 µm, which are tapering upwards to 1.8-2.2 µm beneath the spore. Zygospores 17-22 µm in diam., dodecahedral in outline, with unevenly thick epispore.

Distribution and hosts. Australia, Queensland; parasite of nematodes, found in arable soils under tomato, ginger and peanut.

FAMILY *MERISTACRACEAE* Humber

Meristacraceae Humber, Mycotaxon 34: 456-457. 1989.

Mycelium endobiotic, consisting of hyphal bodies usually elongate, sometimes of the appearence of hyphae with some cross walls. Nuclei ancylistoid. Conidiophores continuous or septate, protruding from hyphal bodies, perforate host's cu-

tacle. Primary conidia produced in numbers from few to several dozen laterally on septate terminal part of the conidiophore or on ampulliform conidiogenous cells, or short narrow pedicels formed acropetally in sympodial succession during the growth of a conidiophore and maintaining laterally (Fig. 6e). Primary conidia globose to obovate, sometimes rough or echinulate, forcibly discharged, only in representatives of the genus *Zygnemomyces* passively detached. Conjugation scalariform or unknown. Zygospores globose, elongate or obtusely-polyhedral of round outline, thick walled. Pathogens of small invertebrates in moist habitats, one species known from the larvae of big flies (*Tabanidae*). Separation of this family has been proposed by Humber (1989); the group is known very weakly.

Key to genera

1. Conidiophores in upper part septate forming a linear series of conidiogenous cells in basipetal succesion; primary conidia pear-shaped, formed laterally on particular cells and thrown away by papilla eversion; pathogens of nematodes and insects . . . . . *Meristacrum*, p. 8
1*. Conidiophores nonseptate; sporegenous cells or conidium-bearing pedicels growing sympodially 2
2. Conidiogenous cells ampulliform or slightly inflated but always separated from the conidiophore by their own walls and arranged acropleurogenously, usually in great numbers; primary conidia ejected by „sporophore rocket" mechanism; parasites of tardigrades . . . *Ballocephala*, p. 9
2*. Primary conidia borne on thin conical or hook-like pedicels not separated by cross-wall from the conidiophore, passively detached; parasites of nematodes . . . . . *Zygnemomyces*, p. 9

Genus *Meristacrum* Drechsler emend. Tucker et Humber

Meristacrum Drechsler, J. Wash. Acad. Sci. 40: 250-251. 1940; — Tucker, Mycotaxon 13: 481-505. 1981.

Vegetative mycelium developing inside host, consisting at first of simple to somewhat branched, continuous hyphae dividing by septa and disjoining with age. Conidiophores protruding from the hyphal segments through animal's cuticle and divide successively forming several cells, each of which produces a single spore forcibly discharged by papilla eversion. Secondary spores of the same type or pas

sively detached. Resting spores zygospores formed in result of conjugation of spherical, uninucleate gametangia, or azygospores originating from hyphal segments. Parasites of nematodes and insect larvae.

Type species: *Meristacrum asterospermum* Drechsler.

Two subsequent nuclear divisions have been observed at the germination of the diploid uninucleate zygospores of *M. milkoi* (Dudka et Koval) Humber (Couch et al. 1979), giving the spore formation analogous as in certain cases of the rust fungi. Thus, according to the above quoted reference the primary spores should be called meioconidia.

Key to species

1. Sporophores often coiled; primary conidia obovate 2-15 on each sporophore, secondary spores passively detached; azygospores spherical of the surface undulate in outline; parasite of nematodes . . . . . *M. asterospermum*, p. 89

1*. Sporophores straight or curved; primary spores pyriform with wart-like papillae, commonly 4 on each sporophore; secondary conidia similar; zygospores ovoid, punctate; parasite in larvae of *Tabanidae* (*Diptera*) . . . . . *M. milkoi*, p. 90

(1). *Meristacrum asterospermum* Drechsler

Meristacrum asterospermum Drechsler, J. Wash. Acad. Sci. 30: 250. 1940; — Davidson et Barron, Canad. J. Bot. 51: 231-233. 1973.

Host's body filled with at first non-septate hyphae 50-500 x 5-12 µm, disjoining into the hyphal bodies 25-60 µm long. Sporophores successively septate, several dozen micrometers to about half a milimeter long and 5-9 µm thick, sometimes thinner, 3-5 µm, usually spirally coiled at end. Primary spores obovoid with truncate base, 8-11 x 6-8 µm (after Drechsler 1940), 7-17.5 x 6-10 µm (after Davidson & Barron 1973), produced in number of 2 to 15 on each conidiophore in basipetal succession. Secondary spores of the same type. Resting spores spherical, 15-20 µm in diam., with undulate wall surface; conjugation has not been observed.

Distribution and host. North America — USA and Canada, obligate parasite in terricolous nematodes.

(2). *Meristacrum milkoi* (Dudka et Koval) Humber

Meristacrum milkoi (Dudka et Koval) Humber, Mycotaxon 13: 232. 1981; — *Coelomomyces milkoi* Dudka et Koval in Dudka, Koval et Andreeva, Novosti Sistematiki Nizsich Rastenij, 10: 89. 1973; — *Pseudocelomomyces milkoi* (Dudka et Koval) Nam et Dubitskii, Inst. Zool. Alma-Ata, Acad. Sci. Kazakh. SSR (ViuTI no. 1309-77 Dep.) 1977 (comb. inval.); — *Tabanomyces milkoi* (Dudka et Koval) Couch, Andreeva, Laird et Nolan, Proc. Natl. Acad. Sci. USA 76: 2299-2302. 1979.

Mycelium inside insect larvae initially continuous, becoming septate with age in the form of elongate hyphal bodies giving rise to globose or subspherical colorless, smooth gematangia, 12-18 μm in diameter. Zygospores monokaryotic, ovoid, 23-30 x 12-20 μm, colourless, with two-layered smooth wall 2-4 μm thick, containing finely granular cytoplasm. Germinating zygospores form single sporophore succesively dividing typically into four cells, each of which produces laterally one monokaryotic pear-shaped spore, 12-16 x 10-13 μm., forcibly discharged by papilla eversion mechanism. Secondary spores of the same type.

Distribution and hosts. Eastern Europe — Ukraine, parasite in larvae of horse flies *Tabanus autumnalis* L. and *Chrysops relictus* Meigen (*Diptera*: *Tabanidae*).

Genus *Ballocephala* Drechsler

Ballocephala Drechsler, Bull. Torrey Bot. Club 78: 199. 1951.

Mycelium consisting of elongate, non-septate hyphal bodies almost equally narrow. Conidiophores non-septate producing at distal end ampulliform or somewhat inflated conidiogenous cells in sympodial succesion, arranged laterally in subapical part, in numbers from few to several dozen. Primary conidia globose, small, ejected by the mechanism of „sporophore rocket" together with colarettes from the ends of conidiogenous cells. Zygospores polyhedral to elongate, almost cylindric, smooth or punctate. Pathogens of tardigrades.

Type species: *Ballocephala sphaerosperma* Drechsler.

Key to species

1. Conidiogenous cells ampulliform, so big as or greater than primary conidia, arranged on almost all lenght of conidiophore 2
1*. Conidiogenous cells slightly inflated, smaller than conidia, arranged in subapical clusters . . . . . *B. pedicellata*, p. 91

2. Primary conidia smooth, without any ornamentation . . . . . *B. sphaerosperma*, p. 91
2*. Primary conidia verruculose . . . . . *B. verrucospora*, p. 91

(1). *Ballocephala sphaerosperma* Drechsler

Ballocephala sphaerosperma Drechsler, Bull. Torrey Bot. Club 78: 183-200. 1951.

Hyphal bodies elongate, 40-80 x 5-10 µm, seldom with one cross-wall. Conidiophores upright 50-175 x 4-5 µm, bearing in upper, slightly attenuated part about 20-80 small, ampulliform, often somewhat assymmetrical sporogenous cells, 4-7 x 3-4.5 µm, in spicate arrangement. Primary conidia smooth, globose, 3-4.5 µm in diam., after discharge with rudimentary colarette of sporogenous cell at the base. Zygospores elongate, ellipsoid, 17-20 x 13.5-16 µm, surrounded by 6-8 µm thick, brown walls, produced singly in zygosporangia, 28-33 x 14-16.5 µm, of 3-4 µm thick walls.

Distribution and host. North America, in the tardigrades *Macrobiotes* spp.

(2). *Ballocephala verrucospora* Richardson

Ballocephala verrucospora Richardson, Trans. Brit. Mycol. Soc. 55: 308. 1970.

Hyphal bodies elongate 20-40 x 10-12 µm, with cross walls. Conidiophores 50-150 x 5-7 µm, producing in acropetal succession 4-12 subglobose sporogenous cells of the diameter 5-7 µm, arranged acropleurogenously at the distal end of the sporophore. Primary conidia globose, 4.5-6 µm in diam., echinulate or finely verrucose on the surface, with scarcely seen basal colarette. Resting spores unknown.

Distribution and hosts. Great Britain; parasite in tardigrades.

(3). *Ballocephala pedicellata* Pohlad et Bernard

Ballocephala pedicellata Pohlad et Bernard, Mycologia 70: 131. 1978.

Hyphal bodies elongate, thick, 20-31 x 13-16 µm, protruding into conidiophores 33-73 µm long with small, ovoid to subglobose conidiogenous cells (1.1-) 1.6-2.6 x 2.1 µm, scattered in number 2-10 along their top parts. Primary conidia globose, smooth 6.8-8 µm in diam., with distinct basal colarette. Zygospores poly-

gonal in outline, brown, thick-walled, punctate on the surface, 20.6-26.6 x 17.3-18.6 µm, formed in result of isozygogamy of hyphal bodies.

Distribution and hosts. North America, USA-Georgia, parasite in tardigrades *Hypsibius dujardini* (Doyere) and *Diphascon pinguis* Marcus (*Hypsibiidae*).

Remarks. Inside a carapace of the adult oribatid mite *Adoristes ovatus* (C. L. Koch) collected in decayed willow wood in forest distr. Babki near Poznań (leg. J. Wiśniewski, 8 May, 1983) smooth globose spores 6.8-9.4 (-11.7) µm in diam., of thin brown walls, with the colarette characteristic for the conidia of *Ballocephala* were found.

Genus *Zygnemomyces* Miura

Zygnemomyces Miura, Rep. Tottori Mycol. Inst. 10: 520. 1977.

Unsegmented hyphae, filling host's body cavity grow through its cuticle forming nonseptate conidiophores, bearing primary conidia on few sympodially originating pedicels. The spores passively detached; secondary spores unknown. Zygospores irregularly multiangular, thick walled, forming after lateral or scalariform conjugation. Parasites of nematodes.

Type species: *Zygnemomyces echinulatus* Miura.

The spores of hiterto known species are globose and echinulate.

Key to species

1. Spore-bearing pedicels form an acute angle with the distal part of the sporophore, apex of the latter straight; spores numerous . . . . . *Z. echinulatus*, p. 92

1*. Spore-bearing pedicels directed downwards, forming an acute angle with the proximal part of the sporophore; apex of the latter usually hooked; spores few . . . . . *Z. pendulatus*, p. 93

(1). *Zygnemomyces echinulatus* Miura

Zygnemomyces echinulatus Miura, Rep. Tottori Mycol. Inst. 10: 520. 1977.

Host's body filled with a network of thin continuous hyphae of the diameter 2-5 µm giving rise to the sporophores about 100-750 x 2.7-5.7 µm, which produce relatively numerous spore-bearing pedicels 1.5-3 x 0.5-1.1 µm directed obliquely

upwards. Spores globose, delicately echinulate. Zygospores irregular, brown 16-24 μm in diam., resulting from the scalariform conjugation between equal gametangia forming together a zygosporangium 22-28 μm thick.

Distribution and hosts. Japan, on nematodes.

(2). *Zygnemomyces pendulatus* (McCulloch) Tucker

Zygnemomyces pendulatus (McCulloch) Tucker, Mycotaxon 13: 495-497. 1981. — *Meristacrum pendulatum* McCulloch, Trans. Brit. Mycol. Soc. 69: 175. 1977.

Hyphae inside the host body continuous, 2-5 μm thick. Sporophores erect, unsegmented, 18-71 x 2-3 μm, forming sympodially few thin, hook-likely directed downwards spore-bearing pedicels, 1-3 x 0.8-1.2 μm. Spores passively detached, epapillate, globose, 5-8 μm diam., echinulate. Resting spores thick walled, irregularly tetra-to hexangular in outline; the way of their formation unknown.

Distribution and hosts. Australia, Queensland, parasite of nematodes in arable soil under pineapple culture.

FAMILY *ENTOMOPHTHORACEAE* Nowakowski

Entomophthoraceae Nowakowski, Bot. Ztg. 34 /14/: 216-222. 1877 (Entomophthoreen). *Empuscaceae* Clements et Shear, Gen. Fung. p. 37. 1931.

Vegetative mycelium develops internally in host's body cavity or its particular cells forming oligokaryotic globose, ovoid, granular, elongated or polymorphic hyphal bodies or poorly septate hyphae, usually easily fragmented into particular segments. Nuclei entomophthoroid. Conidiophores usually differentiated from the vegetative mycelium, protruding from hyphal bodies or submerged hyphae as cylindric, bottle-shaped or clavate, unbranched structures, terminated with a single conidium, or dichotomously or digitately branched in top part, forming one conidium on the end of each terminal branch. Primary conidia mono- or oligokaryotic, globose, bell-shaped, pyriform, obovoid, turbinate or elongate, with truncate, convex or conical papillae, surrounded by one- or two-layered external wall; in the latter case the outer layer is interrupted on papilla. Conidium discharge mechanism of „sporophore cannon"-type or common papilla eversion, except of representatives of the genus *Massospora* Peck, where the spores are passively de-

tached. Secondary conidia different types of the ballospores, or passively detached capilliconidia, rarely elongate spores of rudimental discharge mechanism. Resting spores globose, subspherical or ovoid, hyaline or coloured, smooth or ornamented on the surface, of zygogamic or apogamic origin. Specialized pathogens of arthropods, mainly insects, one species phytopathogenic in fern gametophytes.

In numerous, particularly older, mycological reviews and manuals the order *Entomophthorales* was divided into two families, *Basidiobolaceae* and *Entomophthoraceae* and both zoophilic and detritophagous species of ancylistoid nuclei were included into the latter. According to lately established criteria based on karyology the families *Ancylistaceae* and *Meristacraceae* have been treated here as seperate ones, whereas for practical reasons — mostly for difficulties in determination of submicroscopical fine features in nuclear structure — representatives of proposed families *Neozygitaceae* and *Completoriaceae* have been left in *Entomophthoraceae.*

Key to genera

1. Conidia unitunicate (or cryptobitunicatae), di-, oligo- or polykaryotic 2
1*. Conidia distinctly bitunicatae, monokaryotic 9

2. Conidiophores in apical parts furcate or monopodially branched often intermixed with those unbranched; conidia obovoid or elongate; rhizoids present or absent . . . . . *Eryniopsis*, p. 130
2*. Conidiophores unbranched, quite exceptionally furcate at the base . 3

3. Phytopathogenic species; thallus intracellular in form of hyphal bodies filling cells of fern gametophytes . . . . . *Completoria*, p. 112
3*. Zoopathogenic species; mycelium develops in body cavity of invertebrates causing decay of particular tissues and organs and usually grows externally after host's death 4

4. Parasites of nematodes and tardigrades . . . *Macrobiotophthora* p. 86 . . . . . (see family *Ancylistaceae*)
4*. Pathogens of arthropods, mainly insects and arachnoids 5

5. Conidial sporulation inside the exoskeleton of arthropods; conidia usually dikaryotic (exceptionally single mono- or trikaryotic spores may occur), often of rough or ornamented surface, passively detached; pathogens of gregarious cicads . . . . . *Massospora*, p. 145
5*. Conidial sporulation external, conidia forcibly discharged, with smooth, unornamented, adhesive wall 6

6. Nuclei uniformly stained without darker heterochromatic threads; zygospores dikaryotic, black-brown, produced in conjugative bridge between conjugating hyphal bodies; conidia with fumose wall, typically tetrakaryotric to octokaryotic, with truncate or at least slightly convex papilla; capilliconidia usually present . . . . . *Neozygites*, p. 133

6*. Nuclei stained unevenly, with visible darker spots and threads; resting spores with different numbers of nuclei, globose to ovoid, produced from the maternal gametangium, often only azygospores known; conidia di- to polykaryotic — if the number of nuclei is small then primary conidia of the truncate bell-shaped type; capillispores lacking 7

7. Primary conidia bell-shaped with truncate papillae 2- to about 20-30-nucleate; secondary conidia similar . . . . . *Entomophthora*, p. 95

7*. Primary conidia oligo- to polykaryotic, having regularly more than 15 nuclei, globose with large and distintly convex papillae or pear-shaped; secondary conidia similar to the primary or strongly elongated 8

8. Primary conidia globose with abruptly protruding papillar convexity of semispherical shape, often with small sharp point in the center; conidiophores distended in apical part, mildly narrowed and elongated into relatively long neck; rhizoids — if present — monohyphal, ended with disc-like holdfasts . . . . . *Batkoa*, p. 106

8*. Primary conidia pear-shaped mildly narrowing downwards and closed with non-apiculate papillar convexity; conidiophores clavate without neck-like narrowing or only with very short one; rizoids absent . . . . . *Entomophaga*, p. 113

9. Conidiophores unbranched; sporulation in subspherical capsules inside host's abdomen, opened on the sternal side; rhizoids lacking . . . . . .*Strongwellsea*, p. 143

9*. Conidiophores dichotomously or digitately branched; sporulation external; rhizoids and pseudocystidia normally present *Zoophthora*, p. 147

Genus *Entomophthora* Fresenius ss. Remaudière et Keller

Entomophthora Fresenius ss. Remaudière et Keller, Mycotaxon 11: 332. 1980; — *Entomophthora* Fresenius, Bot. Ztg. 14. 882. 1856, p.p. (nec Nowakowski, Pam. Akad. Umiej., Wydz. Mat.-Przyr. 8: 175-176. 1883).

Empusa Cohn, Nova Acta Acad. Caes. Leop.-Carol. Germ. Nat. Curios. 25: 301-360, 1855 (nec Lindley, Bot. Regn. sub. t. 825. 1824); — *Myiophyton* Lebert Neue Denkschr. Schweiz. Gesellsch. Naturwiss, 15: 26.1856; Virchow's Arch. 12: 69-79. 1857; — *Lamia* Nowako-

wski, Pam. Akad. Umiej., Wydz. Mat.-Przyr. 8: 1883 (nec Endlicher, 1841); — *Culiccola* Nieuwland, Am. Midl. Nat. 4. 378. 1916.

Vegetative mycelium develops in the body cavity of infected host, in some cases only in its abdomianl part, forming round, ovoid, ellipsoid or somewhat irregularly elongate hyphal bodies. Conidiophores oligokaryotic, unbranched, grow from the hyphal bodies as non-septate, parallelepipedous hyphae, clavate widened in top part after perforating host's cuticle. Primary conidia unitunicate (cryptobitunicate), oligokaryotic, bell-shaped — truncata campaniformis after Lakon's (1919) classification — ovoid in outline, with truncate or very slightly convex papilla and distinct, small apiculate or wart-like point in the center of the rounded top part. Resting spores round, thick-walled azygospores. Rhozoids present or absent. Monophagous and oligophagous insect pathogens.

Type species: *Entomophthora muscae* (Cohn) Fresenius.

The generic name *Entomophthora* was in the past applied for practically all entomophthoralean species except *Massospora* Peck. Recent critical reviews by Batko (1964, 1974a), Remaudière and Keller (1980), Humber (1981) and Ben-Ze'ev and Kenneth (1982) allowed to link this name only to the species forming cryptobitunicate, oligokaryotic, bell-shaped primary conidia of truncate papilla on unbranched conidiophores. MacLeod et al. (1976) recognized 5 species basing on general morphology. Recently applied karyological criteria (Keller 1984, 1987; Ben-Ze'ev & Zelig 1984) allowed to separate 13 species from which 8 have been reported from Poland.

Key to species

1. Conidial sporulation begins on still alive, moving hosts; rhizoids absent 2
1*. Conidial sporulation begins on hosts post mortem; rhizoids present or absent, in some cases indistinct 3

2. Pathogens of raphidid larvae (*Raphidioptera*) . . . . *E. weberi*, p. 106
2*. Pathogen of mirid bugs (*Adelphocoris* and allied) . . *E. erupta*, p. 100
2**. Pathogens of *Thrips tabaci* Lind. . . . . *E. thripidum*, p. 105

3. Pathogens of adults dipterans 4
3*. Pathogens of other insects 10

4. Pathogens of *Brachycera* and *Cyclorrrhapha*; development of rhizoids limited to proboscis; hyphal bodies in abdominal part rather regularly globose; primary conidia contain more than 4-nuclei 5
4*. Pathogens of *Nematocera*; rhizoids grow through sternal sutures of diffe-

rent parts of host's body, or — if rhizoids grow through mouthparts — primary conidia typically 3-nucleate (exceptionally 2 or 5) and hyphal bodies of less regular shapes 7

5. Primary conidia 16-25 x 12-22 µm, containing 3-7 large nuclei each (typically 4-7 nucleate), the diameter of nuclei 5-7 µm; on *Hylemya* spp. and *Pollenia rudis* . . . . . *E. schizophorae*, p. 103

5*. Primary conidia 21-36 x 16-30 µm containing typically over 10 and up to 30 nuclei of the diam. 3-4 µm 6

6. On calyptrate flies mostly of the families *Muscidae* and *Calliphoridae*; primary conidia (6-) 10-22 (-30)-nucleate . . . . . *E. muscae*, p. 97

6*. On *Scatophagidae*; primary conidia 12-19 nucleate . . . . . *E. scatophagae*, p. 103

6**. On *Syrphidae*; primary conidia 27-31 x 22-24.4 µm; 16-24 nucleate, papilla 12-14 µm wide . . . . . *E. syrphi*, p. 104

7. Primary conidia 10-22 x 8-19 µm, typically 4-10 (3-13)-nucleate; nuclei about 3 µm in diam. . . . . *E. brevinucleata*, p. 98

7*. Primary conidia of similar size or smaller, with 1-15 nuclei of usually greater diameter 8

8. Primary conidia 12-15 x 8-11 µm, typically 2, seldom 3-nucleate; on *Culicidae* and *Chironomidae* dying just over water surface in wet habitats . . . . . *E. culicis*, p. 99

8*. Primary conidia greater, 1-5 nucleate 9

9. Primary conidia 15-19 x 11-16 µm, 3-4 seldom 5-nucleate; nuclei usually 3-4 µm in diam; rhizoids grow through mouthparts and end of abdomen . . . . . *E. israelensis*, p. 102

9*. Primary conidia 16-22 x 12-18 µm, typically 3 (2-5)-nucleate; nuclei larger — 5-6.5 µm in diam; rhizoids grow through moutparts, sometimes indistinct . . . . . *E. trinucleata*, p. 105

10. Rhizoids present; primary conidia 15-23 x 11-19 µm, 4-11-nucleate; on aphids . . . . . *E. planchoniana*, p. 102

10*. Rhizoids absent; primary conidia 16-24 x 12-19 µm, 6-18-nucleate; on mirid bugs . . . . . *E. helvetica*, p. 100

1. *Entomophthora muscae* (Cohn) Fres.

Entomophthora muscae (Cohn) Fres. Bot. Ztg. 14: 882. 1856; — *Empusa muscae* Cohn, Nova Acta Acad. Caes. Leop.-Carol. Germ. Nat. Curios. 25: 301-360. 1855; Hedwigia 1: 60. 1855; — *Myiophyton muscae* (Cohn) Lebert ex Krenner, Acta Bot. Acad. Sci. Hung. 7: 363. 1961.

Myiophyton cohni Lebert, Neue Denkschr. Allg. Schweiz. Gesammt. Naturwiss. 15: 26. 1857.

Hyphal bodies in the host's abdominal part subglobose to broadly ovoid, 20-40 x 18-35 µm, developing from generally subspherical protoplasts shortly before the death of the host and producing one, seldom two, unbranched hyphae 6-8 µm thick, perforating the insect cuticle in sutures between abdominal sclerites and terminating with slightly distended, claviform conidiogenous cells 75-120 x 22-27 µm. In thoracical part and in the head hyphal bodies are elongate, somewhat rod-shaped 25-70 x 8-20 µm, sometimes with one cross-wall. Primary conidia 20-32 x 15-28 µm, usually 10-22-nucleate, occasionally single of them may contain 6-9 or 23-30 nuclei. Papillae truncate or very slightly convex; apical point distinct but rather short. Secondary conidia of the same type, smaller and in further series devoid of apical point. Rhizoids grow through mouthparts forming a compact network of hyphae with liguliform or lobate outgrowths radially arranged around the labellum. Resting spores unknown.

Distribution and hosts. Reported in the references from the world over, however these records concern a collective taxon understood at present as „*Entomophthora muscae*-species complex", comprising at least five distinct species. The typical host is *Musca domestica* L. (*Diptera, Cyclorrhapha Schizophora, Calyptrata*) and few other species of calyptrate flies, but in references have also been reported species belonging to other brachycerous dipteran groups, mostly *Syrphidae* (*Cyclorrhapha Aschiza*), *Drosophilidae* (*Cyclorrhapha Schizophora, Acalyptrata*) and even *Empididae* (*Orthorrhapha*). The studies aiming to solve the problem of interrelationships between host specificity, morphology — mainly karyology — and development cycle synchronisation from the taxonomical point of view have been carrying out.

Occurrence in Poland. Common in all the country especially in late summer and autumn on *Musca domestica* L., *Pollenia rudis* Fabr. and some unidentified species. All earlier reports concerning this species and its hosts have to be verified with regard to agreement with currently applied taxonomical criteria.

Remarks. Four specimens of the house fly (*Musca domestica*) overgrown by the Jungs were deposited in the WRSL Herbarium with the following label: „1973. Empusa muscae Cohn nov. gen et spec. Hedwigia N. 10 Entophyta; in muscae domesticae alvo evolvens, demum erumpens. Dr FERD. COHN." The mycelium is in poor condition and only jew primary conidia of the dimension range (24-) 26.5-29.5 (-31) x (18.5) 22-24 (-25) µm have been found among numerous secondary ones.

2. *Entomophthora brevinucleata* Keller et Wilding

Entomophthora brevinucleata Keller et Wilding, Entomophaga 30: 56. 1985; — Keller, Sydowia 40: 152-154. 1987.

Hyphal bodies at the time of hos's death subspherical to ellipsoid, about 20-40 x 15-30 µm, germinating with a single hypha and forming unbranched conidio-

phores or fragmenting onto elongate hyphal bodies of the dimensions about 35-70 x 6-14 μm or rod-shaped, thicker and shorter, 22-31 x 17-24 μm. Conidiogenous cells typically clavate distended. Primary conidia (10-) 11-19 (-22) x (8-) 8.5-16 (-19) μm of L:D ratios 1.14-1.29, typically 4-10-nucleate (extreme numbers of nuclei 3-13). Rhizoids monohyphal or tangled into loose bundles, especially those arising through the mouthparts typically 6-9 μm wide, (exceptionally 5-14 μm), without specialized holdfasts at ends.

Distribution and hosts. Western Europe (Switzerland, Great Britain) on adult midges (*Diptera*: *Cecidomyiidae*), among them *Sitodiplosis phalaridis* Kieff., *Contarinia pisi* (Winn.), *Mycodiplosis* sp.

Occurrence in Poland. Wielkopolski National Park, hardwood forest Puszczykowo, on a small *Cecidomyiidae* attached to a leaf in forest undergrowth, 31 May, 1992.

3. *Entomophthora culicis* (A. Braun) Fres.

Entomophthora culicis (A. Braun) Fres., Abh. Senckenberg. Naturf. Gesellsch. 2: 206. 1858. — *Empusa culicis* A. Braun, Algarum unicellularum genera nova. Lipsiae: 105. 1855; — *Lamia culicis* (A. Braun) Nowakowski, Pam. Akad. Umiej., Wydz. Mat. Przyr. 8: 173. 1883. — *Culicicola culicis* (A. Braun) Nieuwland, Am. Midl. Nat. 4(8): 378. 1916. — *Myiophyton culicis* (A. Braun) v. Arx. The genera of fungi, p. 51. 1970.
Entomophthora rimosa Sorokin, Hedwigia 15: 147. 1876.

Hyphal bodies 1-16 nucleate subspherical, irregularly ovoid or elongate, 25-45 x 12-25 μm, or in form of longer hyphal segments sometimes divided by 1-3 cross-walls. Conidiophores unbranched, terminated with slightly distended conidiogenous cell 60-95 x 8-12 μm. Primary conidia 11-16 x 7-12 μm, typically 2-nucleate, seldom 3-nucleate, the widest just over the half of their lenght, slightly attenuated towards truncate base 6-9 μm broad. Secondary conidia similar, smaller, in further series devoid of apical point. Resting spores spherical to somewhat subglobose, (21-) 24-27(-29-) μm in diam. surrounded by the wall about 2.5 μm thick, smooth, of the epispore appearing to be slightly darkened.

Distribution and hosts. Europe, North America, Asia, on small gnats, mostly *Culicidae* and *Chironomidae*, but also repoprted from *Simuliidae* and *Empididae*.

Occurrence in Poland. On *Chironomidae* and *Culicidae* at banks of rivers and streams and around lakes, ponds and pools, in peat bogs and marshes, just over water surface; often epizootic (Fig. 14). The first infected specimens appear usually in the second half of June and after about one week the sharp peaks of mortality have regularly been observed.

(4.) *Entomophthora erupta* (Dustan) Hall

Entomophthora erupta (Dustan) Hall, J. Ins. Pathol. 1: 48. 1959; — *Empusa erupta* Dustan, Proc. Acad. Entomol. Soc. 9: 31. 1924.

Hyphal bodies ovoid or elongate, 12-19 µm thick, develop in abdominal part of host's body, producing thinner, parallelepipedous hyphae terminated with somewhat swollen conidigenous cells. Primary conidia produced on still alive hosts, typically 3-4-nucleate, rarely with 1-2 or 5 nuclei, 17-23x 11-16 µm; their papillae rather broad. Secondary conidia smaller, usually without apical point. Resting spores globose or subspherical 30-40 µm in diam., 1-3-nucleate, with a large central oil globule, surrounded with walls 3.5-7 µm thick, of smooth, pretty thick, brown epispore. Resting spores occur in the whole cavity of host's body including head and thoracical parts, contrary to the mycelium producing conidia only, which is restricted to the abdominal part. Rhizoids lacking.

Distribution and hosts. North America (Canada and United States) on a number of mirid bug species: *Adelphocoris lineolatus* (Goeze), *Irbisia solani* (Heidemann), *Lygus communis* var. *novascotiensis* Knight, *Lygus pabulinus* (L.), *Plagiognathus* sp.

Remarks. Keller's (1981) report or the occurrence of this species in Switzerland on *Notostira elongata* Geoffr. (*Heteroptera*: *Miridae*) appeared erroneous after re-examination and comparison with the type material (Ben-Ze'ev et al. 1985). Results of these detailed studies allowed to separate a further species *E. helvetica* Keller et Ben-Ze'ev (see below).

(5). *Entomophthora helvetica* Keller et Ben-Ze'ev

Entomophthora helvetica Keller et Ben-Ze'ev in Ben-Ze'ev, Keller et Ewen, Cand. J. Bot. 63: 1471-1472. 1985.

Hyphal bodies of different shapes, subspherical, ovoid, claviform or hyphal segment like, fill entire host's body cavity. Conidiogenous cells elongate, somewhat claviform, 11-23 µm wide. Primary conidia 8-13-nucleate, almost round or short ovoid in outline but with distinctly marked truncate-campaniform shape, with rather indistinct apical point, 16-24 x 12-19 µm; papilla relatively narrow — of about half of the total conidium diameter — slightly arcuate in outline. Secondary conidia similar, without marked apical point. Immature resting spores observed once by Keller (1981) were subspherical, 23-32 µm in diam. thin-walled. Rhizoids lacking.

Distribution and hosts. Western Europe (Switzerland), on *Notostira elongata* Geoffr. (*Heteroptera*: *Miridae*). Detailed data on the morphology, histopathology, epizootiology and taxonomy — see Keller (1981) and Ben-Ze'ev et al. (1985).

Fig. 14. *Entomophthora culicis* on chironomid adults attached to moist wood on the water surface (Wielkopolski National Park).

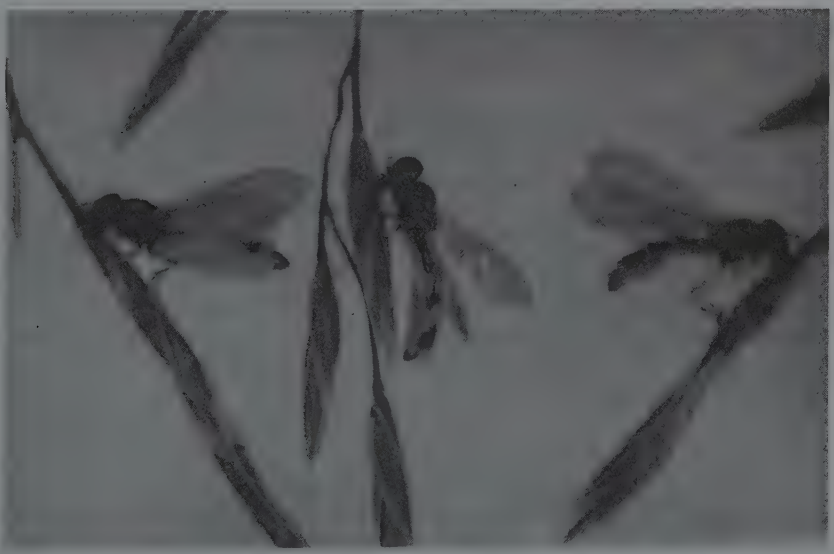


Fig. 15. *Entomophthora syrphi* on *Melanostoma scalare* attached to grasses (Wielkopolski National Park).

(6). *Entomophthora israelensis* Ben-Ze'ev

Entomophthora israelensis Ben-Ze'ev, Mycotaxon 21: 463 — 474. 1984.

Hyphal bodies pyriform or of the shapes of rather short hyphal segments of rounded ends, those growing inside legs longer, filamentous, of uneven width. Conidiogenous cells cylindric to somewhat clavete, 3-8-nucleate. Primary conidia 3-5-nucleate, of the truncate-capaniform type, 15-20 x 11-16 µm (av. 16,7x13 µm), of rather ovoid or almost subglobose shape in general outline, but with relatively long, conical apical outgrowths and rather narrow, weakly arcuate papillae. Secondary conidia without apical outgrowths, produced on very short tubular sporophores. Resting spores unknown. Rhizoids monohyphal without specialized terminal holdfasts, grow through the host mouth-parts and from pygidial section.

Distribution and host. Israel, on adult cecidomyid midges attached to young citrus leaves. Known only from the type locality.

7. *Entomophthora planchoniana* Cornu

Entomophthora planchoniana Cornu, Bull. Soc. Bot. France 20: 189. 1873; — *Myiophyton planchonianum* (Cornu) v. Arx, The genera of fungi: 51. 1970; (nec *Empusa planchoniana* (Cornu)? ex Thaxter, Mem. Boston Soc. Nat. Hist. 4: 165-166. 1888).

Entomophthora chromaphidis Burger et Swain, J. Econ. Entomol.11: 288. 1918; — *Culicicola chromaphidis* (Burger et Swain) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 404. 1964.

Hyphal bodies ellipsoid or elongate, approximately 20-50 x 12-20 µm, mostly about 30 x 16 µm, with numerous vacuoles and 3-12 nuclei, germinating with one hypha 6-7.5 µm thick. Conidiogenous cells distended up to 12-18 µm in upper part, 5-10-nucleate, most frequently with 7-8 nuclei. Primary conidia 6-8 nucleate, 15-20 x 13-17 µm of rather broad bases, slightly arcuate papillae and narrow, sharp apical point. Conidial sporulation appears usually on the dorsal side of abdominal part of host's body. Secondary conidia smaller, without apical point. Rhizoids numerous, often somewhat tangled forming short, loose fascicles. Resting spores globose, (27-) 30-37 (-42) µm, surrounded with walls 2.5-3 µm thick of dark, uneven spispore.

Distribution and hosts. The fungus is common in all continents affecting many aphid species in dry and moderately humid habitats, often causing epizootics; it does not occur in moist sites. In Poland found in all investigated areas, common in summer and autumn, may hibernate in vegetative phase inside aphid cadavers; identified hosts: *Impatientium asiaticum* (Nevsky), *Sitobion avenae* (Fabr.), *Capitophorus similis* v. d. Goot, *Microlophium evansi* (Theob.), *Acyrtosiphon pisum* (Harris), *Aphis fabae* Scop., *Aphis frangulae* Kaltenbach in Koch, *Aulacorthum solani* (Kaltenbach), *Brevicoryne brassicae* (L.), *Cryptomyzus ribis* (L.), *Dre-*

panosiphum platanoidis (Schrank), *Macrosiphum rosae* (L.), *Uroleucon cirsii* (L.), *U. hypochoeridis* Hille Ris Lambers, *U. tussilaginis* (Walker).

Remarks. Hunber and Feng (1991) consider *Entomophthora chromaphidis* Burger et Swain to be a separate species differing by smaller primary conidia and distributed out of Europe.

8. *Entomophthora scatophagae* Giard

Entomophthora scatophagae Giard, Bull. Sci. France Belgique, 19: 308. 1888; — Steinkraus et Kramer, Mycotaxon 35: 105-113. 1988.

Hyphal bodies spherical or subglobose, some 20-30 µm in diam., at the time of host's death germinating by one relatively thick hyphaa, about 9 µm broad. Nuclei round, about 4 µm in diam., hyphal segments sometimes a little ovoid. Sporogenous cells clavate, about 100 µm long and up to 25 µm thick in the upper part. Primary conidia 12-19-nucleate, of almost spherical outline, with short, broad overpapillar neck and strongly prominent, obtuse, mamilliform apical protuberance; their total length is 27-31 µm with the greatest diameter at the half of length — 21-24 µm. Papilla about half so wide as maximum conidial diameter. Secondary conidia usually without or with weakly marked apical protuberance, ca. 20 x 17 µm. Rhizoids — according to references — lacking; host attached to substrate by contraction of legs. Resting spores unknown.

Distribution and host. Europe and North America (see „Remarks" below), on adults of yellow dung flies *Scatophaga stercoraria* L. (*Diptera*: *Scatophagidae*).

Remarks. The above description is based upon the Steinkraus and Kramer (1988) paper supplemented with data on internal mycelium from a specimen found by the author in Poland on the same host species but not investigated karyologically. Related fungus was reported several times from France, Switzerland, Danemark, Germany, Poland, USSR and USA on the same host species, but these materials have not been verified with respect to karyology. Batko (pers. comm.) payed his attention to the generally greater primary conidia of the specimens of „*Entomophthora muscae*" from *S. stercoraria* as compared with related strains from other calyptrate flies (see also Batko and Kmitowa 1962). Although the presence of rhizoids was negated the author (Bałazy 1984) found fungal structures analogous to the affixing hyphae of *E. muscae* in mouthparts of the infected specimen of *S. stercoraria*. Wide discussion on the systematical position of this fungus, vague points and possible mistakes were inserted by MacLeod et al. (1976). Accepting contemporary guidelines in the taxonomy of the entomophthorales at the lower rank levels the treatment of *E. scatophagae* as a separate species is justified.

9. *Entomophthora schizophorae* Keller et Wilding

Entomophthora schizophorae Keller et Wilding in Keller, Sydowia 40: 160-161. 1987.

Hyphal bodies filling the host's abdomen at the time of agony subspherical of the dimensions 20-30 x 17-25 µm, those in thorax and head oblong, some 30-70 µm long and 10-20 µm thick. Round hyphal bodies germinate with single, exceptionally with two, hyphae about 6 µm thick perforating the cuticele between abdominal sclerites including junctions with thorax. Conidiogenous cells cylindric or clavate distended, ca. 80-110 x 17-21 µm, 5-10 nucleate. Primary conidia mostly 5-10 nucleate, almost spherical in outline, 17-25 x 12-22 µm, with hardly marked, very short over-papillar neck approximately as wide as half of the total conidium diameter; apical point distinct, conical rather long. Secondary conidia similar, in first series often with marked apical point, later of regularly obtuse top parts. Resting spores unknown. Rhizoids grow through the proboscis at the time of agony, before sporulation.

Distribution and hosts. Western and Central Europe: Switzerland, Great Britain and Poland, on some species of common anthomyiid flies, often causing epizootics. Until 1987 not differentiated from *E. muscae* (Cohn) Fres., so accessible materials reported up to the present from related hosts should be reviewed.

Occurrence in Poland. Wielkopolski National Park and some other areas in the vicinity of Poznań (Bałazy 1984), on *Hylemya* (*Delia*) *brassicae* Bouche, *Hylemya* (*Delia*) *platura* Meigen, *Hylemya* (*Delia*) *florilega* Zetterstedt and on *Pollenia rudis* Fabr. in Nowy Kraków near Sławno (Northern Pomerania); other preserved materials from anthomyid flies did not allow to undoubt identification.

10. *Entomophthora syrphi* Giard

Entomophthora syrphi Giard, Bull. Sci. France Belg. 19: 308. 1988.

Hyphal bodies about 20-30 nucleate, globose or subglobose, 22-31 µm in diam., protruding by one hypha of uneven thickness 8-12 µm, with numerous sections devoid of protoplasm; nuclei 3-3.5 µm in diam. Conidiogenous cells clavate, about 100 µm long and 18-25 µm thick beneath the tip, salmon pinkish in mass, emerging between sclerites. Primary conidia 27.5-31 x 22-24 µm with over-papillar neck 11.5-13.5 µm wide and about 4 µm long; the greatest diameter distincly over half of the total conidium length. Secondary conidia usually without apical point, often pear-shaped with elongated basal part. Rhizoids of the type of *Entomophthora muscae* growing through mouthparts (Bałazy 1984). Resting spores unknown.

Distribution and hosts. Western and Central Europe, on adults of several syrphid species (*Diptera*: *Syrphidae*) of the genera *Melanostoma, Platycheirus* and *Syrphus*. Known from few localities in Poland (vicinity of Warsaw, Wielkopolski National Park, Turew near Leszno and Jarocin near Kalisz), found also in Karkonosze Mts. in Czech Republic very close to the Polish bor-

derline (Harrachov — leg. Dr. Jeremies from Germany); identified hosts: *Melanostoma scalare* (Fabr.) (Fig. 15), *Platycheirus clypeatus* Meig. *Syrphus tricinctus* Fallen, and *Syrphus* sp.

Remarks. Keller (1984) put this species into „*Entomophthora muscae* complex species" and later (Keller 1987) recognized it, together with the name *E. scatophagae* Giard, as synonyms of *E. muscae* (Cohn) Fres. Highly specialized host range suggests its distinctive physiological character so it has been treated here as a separate species.

(11). *Entomophthora thripidum* Samson, Ramakers et Oswald

Entomophthora thripidum Samson, Ramakers et Oswald, Cand. J. Bot. 57: 1317-1323.

Hyphal bodies elongate of rounded ends, about 20-40 µm long and 8-18 µm thick, multiplicating by budding, sometimes with outhrowths or short branches. Hyphae protruding from the hyphal bodies almost parallelepipedous, about 10 µm thick. Conidial sporulation appears on still alive insects and is limited to the abdominal section of host's body. Conidiogenous cells distended up to about 15 µm, some 70 to about 100 µm long. Primary conidia 10-15 x 8-12 µm of typical shape, with rather obtuse, wart-like apical perturbance and slightly narrowed, truncate base. Secondary conidia similar, with rounded top part or at most with indistinctly marked central convexity. Resting spores unobserved. Rhizoids absent.

Distribution and host: The Netherlands, on *Thrips tabaci* Lind. (*Thysanoptera: Thripidae*) in a glasshouse culture of *Capsicum annuum* L.

12. *Entomophthora trinucleata* Keller

Entomophthora trinucleata Keller, Sydowia 40: 161-162. 1987.

Hyphal bodies at first ellipsoid or somewhat elongate up to about 35 x 5-12 µm in diam., 4-7-nucleate, producing subspherical or somewhat irregularly-shaped, 1 to 5-nucleate, mostly 2-3-nucleate hyphal bodies 18-26 x 13-27 µm. Conidiogenous cells clavate, distended in the upper part up to about 20 µm. Primary conidia usually 3-, seldom 2- or 4-nucleate, short ovoid in outline, with slightly arcuate papillae and very small, delicate but sharply conical apical point, (16-) 17.5-18 (-22) x (12-) 14-15 (-18) µm. Secondary conidia without distinct apical point. Rhizoids grow through mouth-parts, sometimes indistinct. Resting spores unknown.

Distribution and host. Switzerland, on sciarid midges attached to leaves of the maize and *Brassica rapa* L.

Occurrence in Poland. Wielkopolski National Park, on small *Sciaridae* attached to the underside of leaves of forest floor vegetation, found in middle October, 1993 together with *Zoophthora dipterigena*, but much less numerous.

(13). *Entomophthora weberi* (Lakon) Batko

Entomophthora weberi (Lakon) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 403. 1964; — *Empusa weberi* Lakon, Z. angew. Entomol. 26: 518. 1939.

Hyphal bodies spherical to irregular or ameboid, usually 6-nucleate, or as elongate hyphal segments with greater number of nuclei, develop in abdominal part of host's body. Conidial sporulation appears on alive and normally moving insects as cushion-like aggregations of parallel conidiophores growing through pleural sutures of abdominal segments. Primary conidia 12-18 x 11-16 µm (av. 16x13 µm), usually 6-nucleate, typically bell-shaped with truncate base. Resting spores unknown. Rhizoids lacking.

Distribution and host. Germany, on larvae of *Raphidia ophiopsis* L. (*Neuropteroidea*: *Raphidiidae*).

Remarks. According to Weber's (1939) characteristics of the disease symptoms the alive larve with partially deteriorated segments of abdomen may be met.

Genus *Batkoa* Humber

Batkoa Humber, Mycotaxon 34: 446-447. 1989.
Entomophaga subg. *Lichia* Weiser et Batko in Batko et Weiser, J. Invertebr. Pathol. 7: 461. 1965 (nom. nud.).

Vegetative mycelium filamentous or comprising elongate hyphal bodies. Nuclei entomophthoroid well staining in aceto-orcein and Bismarck brown, showing granulate concentrations of heterochromatin, nucleolus eccentric. Conidiophores unbranched with terminal conidiogenous cell strongly distended in subapical part and steadily narrowing into relatively long spore-bearing neck. Primary conidia globose or subglobose forcibly ejected by papilla eversion. Papillae abruptly protruding, semispherical or obtuse conical, often with small sharp point in the center. Pseudocystidia absent. Rhizoids present or absent, if present, they are monohyphal or in loose bunches, ribbon-like with wide disc-like holdfasts at ends. Resting spores arising by budding from parental cells. Pathogens of arthropods.

All species listed in this genus by Humber (1989: 446) except *Batkoa dysderci* (Viégas) Humber had earlier been included into *Conidiobolus* by Remaudière and Keller (1980: 330-331) and in this genus considered

by Ben-Ze'ev and Kenneth (1982). Because of practical identity of the morphology — except of karyological characteristics — of species reported by Keller (1967) under the names *Conidiobolus apiculatus* (Thaxter) Remaudière et Keller and *Entomophaga domestica* Keller as well as *Conidiobolus major* (Thaxter) Remaudière et Keller and *Entomophaga limoniae* Keller, it is necessary to check all accessible materials hitherto reported under the specific epithets „*apiculata*"," *apiculatus*" and „*major*", except Petch's (1944) *Empusa forficulae* var. *major* (see p. 165).

Key to species

1. Rhizoids present; papillae often with small, sharp spine in the center 2
1*. Rhizoids absent; papillae usually without central spine 4
2. Primary conidia pyriform 47-52 x 32.5-35.5 µm, from about half of their height narrowing towards base into wide and relatively long neck ended with strongly convex papilla; on nematocerous flies in wet habitats . . . . . *B. papillata*, p. 112
2*. Primary conidia rather regularly globose, overpapillar neck — if present — very short; on different insects 3
3. Primary conidia together with papillae 30-38 x 29-34 µm; mostly on plant hoppers and flies . . . . . *B. apiculata*, p. 107
3*. Primary conidia together with papillae 48-52 (-57) x 40-47 µm; usually on beetles, hymenopterans and crane flies . . . . . *B. major*, p. 110
4. Primary conidia 80-99 µm in diam., containing 50 or more nuclei; on crane flies (*Diptera*: *Tipulidae*) . . . . . *B. gigantea*, p. 109
4*. Primary conidia together with papillae 35-46 x 30-40 um, containing 17-20 nuclei; on heteropterous bugs *Dysdercus* spp. (*Heteroptera; Pyrrhocoridae*) . . . . . *B. dysderci*, p. 109

1. *Batkoa apiculata* (Thaxter) Humber

Batkoa apiculata (Thaxter) Humber, Mycotacon 34: 446. 1989; — *Empusa apiculata* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 163-164. 1888. — *Lamia apiculata* (Thaxter) Lakon, Z. angew. Entomol. 5: 173-174. 1919. — *Culicicola apiculata* (Thaxter) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 404. 1964. — *Entomophthora apiculata* (Thaxter) Gustafsson, Lantbrukshogsk. Ann. 31: 131-133. 1965. — *Conidiobolus apiculatus* (Thaxter) Remaudière et Keller, Mycotaxon 11: 330. 1980.

Entomophaga domestica Keller, Sydowia 40: 141-143. 1987.

Mycelium filling hosts body cavity consists of ovoid, elongate or slightly polymorphic hyphal bodies, about 25-70 x 12-20 µm, from which filamentous hyphae 5-9.5 µm thick perforating host's cuticle protrude, giving rise the conidiophores. The latter are unbranched, with conidiogenous cells strongly inflated in subapical part, about 70-90 x 22-27 µm, and steadily attenuated towards tip into a 10-15 µm wide neck. Primary conidia almost globose (25,7-)29-34 (-45) x 28-35 µm with short overpapillar ring-like neck and semiglobose papillae abruptly protruding from the conidium outline; papillae 9-10 µm wide and 4.5-6.2 µm long, usually with small sharp point in the center of convexity. Secondary conidia similar, gradually smaller and smaller, mostly with blunt papillae. Rhizoids monohyphal, ribbon-like, broad, ended with wide, round, flat holdfasts of irregularly sinuose margins. Resting spores globose or subglobose, 32-45 µm in diam., filled with evenly globular content when young and surrounded by 2-4 µm thick wall of smooth surface.

The fungus develops well and sporulate on artificial media, especially those containing egg yolk, but also on PDA, forming filamentous cream-white aerial mycelium and septate, often non-contiguous longitudinal hyphae or polymorphic segments of the appearence of hyphal bodies in submerged mycelium. Conidiophores usually not so distinctly inflated as on insects, conidia of typical shape often of greater measurements.

Distribution and hosts. Reported from all continents pathogen of adult insects of different groups, so the fungus seems to be polyphagous.

Occurrence in Poland. Białowieża National Park, Wielkopolski National Park, Szczecin vicinity, Siedlce, Warszawa vicinity, Turew near Poznań, Kościerzyna near Gdańsk; identified hosts from Poland; *Rhagio conspicuus* Meigen, *Sciopus platypterus* Fabr., *Tricholauxania praeusta* Fallen, *Anthomyidae* sp., *Asphondylia* sp., and many other *Diptera* of the families *Anthomyidae*, *Mycetophilidae*, *Psychodidae*, *Scatopsidae*, *Sciaridae* and others, *Arge melanochroa* Gmel. (*Hymenoptera*: *Argidae*), *Harpella forficela* Scop. (*Lepidoptera*: *Oecophoridae*), *Haltica quercetorum* L. (*Coleoptera*: *Chrysomelidae*), *Ledra aurita* L., *Typhlocyba quercus* Fabr. any many other unidentified species of *Auchenorrhyncha*, *Cicadoidea* and *Psylloidea*.

Remarks. The differences between *Conidiobolus apiculatus* (Thaxter) Remaudière et Keller and *Entomophaga domestica* Keller were larger and less numerous nuclei staining well in LPAO in the latter. Moreover, there have been stated considerable differences in isoenzymatic patterns between two respective series of strains (Latgé & Boucias 1984). Having reexamined Thaxter's collection Humber (1989) stated, however, that all materials identified by Thaxter (1888) as „ *Empusa apiculata* Thaxter" — which is the basionym for *C. apiculatus* — had entomophthoroid nuclei of characteristics corresponding fully with those of *E. domestica*. Consequently, he transferred Thaxter's species to the family *Entomophthoraceae* as the type of the new genus *Batkoa* and treated *E. domestica* as a synonym of *B. apiculata*. He suggested simultaneously a possible need to describe Keller's strains of the features of *C. apiculatus* as a new *Conidiobolus* species, which was done three years latter (Keller 1991).

Taking into consideration very wide host range as well as variability in the morphology and peculiarities of nucleus staining the really appearing differences reflect in my opinion complex character of this taxon rather than some features at the generic level.

(2). *Batkoa dysderci* (Viegas) Humber

Batkoa dysderci (Viégas) Humber, Mycotaxon 34: 446. 1989; — *Empusa dysderci* Viegas, Jorn. Agron. 50: 234-253. 1939; — *Entomophthora dysderci* (Viegas) MacLeod et Müller-Kögler, Mycologia 65: 845-847. 1973.

Hyphae filling host's body cavity hyaline, 10-15 µm in diam., cenocytic, at first continuous, subsequently septate and breaking up into particular segments or irregular, inflated hyphal bodies 17-58 µm in diam of outline. Conidiophores at first white, becoming cream to light brown, unbranched; sporogenous cells cylindrical to clavate, 15-20 µm wide in subapical part. Primary conidia almost globose 35-46 x 30-40 µm, 17-20- nucleate, with granular content and several large oil droplets. Papilla large, rather short, semiglobose. Secondary conidia similar, smaller. Rhizoids lacking. Resting spores spherical or ellipsoid, 50-60 µm in diam., polykaryotic, colourless, with rather thin outer wall, little thicker than on conidia, occurring in host's head and legs; they are formed interstitially in the hyphae, singly or in short chains, so they seem to be rather chlamydospores than azygospores.

Distribution and hosts. South America (Brazil), on nymphs and adults of four species of the genus *Dysdercus* (*Heteroptera*: *Pyrrhocoridae*).

Remark. According to Viégas' (1939) observation the conidia seem to be thrown away by means of the „sporophore cannon" mechanism.

(3). *Batkoa gigantea* (Keller) Humber

Batkoa gigantea (Keller) Humber, Mycotaxon 34: 446. 1989; — *Entomophthora gigantea* Keller, Sydowia, 31: 89. 1978; — *Conidiobolus giganteus* (Keller) Remaudière et Keller, Mycotaxon 11: 331. 1980; — *Entomophaga gigantea* (Keller) Keller, Sydowia 40: 142-144. 1987.

Hyphal bodies irregularly amoeboid ca. 30-120 x 20-40 µm, or elongate 40-130 x 16-27 µm (calculated on the basis of Keller's photographs). Conidiophores simple, inflated in the subapical part up to 27-35 µm, flask-shaped, attenuated into rather narrow conidium bearing necks. Primary conidia almost globose, 57-123 x 46-105 µm (ca. 92.2-8.8 x 76.6-8.6 µm), with largely globular centent, about 50-100-nucleate; papillae obtuse conical with rounded ends, rather abtuptly protruding, about 20 µm wide at the base and 15-17 µm long. Secondary conidia similar,

smaller. Rhizoids lacking. Resting spores globose (47-) 58-70 (-93) µm, hyaline, smooth of the walls several micrometers thick, formed from hyphal bodies or hyphae by azygosporic manner.

The fungus grows and develops well on media containing egg yolk and on SDA, but the growth on the latter is slower. The conidia produced in cultures were similar to those from insects whereas resting spores were distinctly larger.

Distribution and host. Central Europe (Switzerland), on adults of *Tipula paludosa* Meig. (*Diptera*: *Tipulidae*).

4. *Batkoa major* (Thaxter) Humber

Batkoa major (Thaxter) Humber, Mycotaxon 34: 446. 1989; — *Empusa apiculata* var. major Thaxter. Mem. Boston Soc. Nat. Hist. 4: 164-165. 1888; — *Lamia apiculata* var. *major* (Thaxter) Lakon, Z. angew. Entomol. 5: 174. 1919; — *Entomophthora major* (Thaxter) Gustafsson, Lantbrutkshogsk. Ann. 31: 133-134. 1965; — *Conidiobolus major* (Thaxter) Remaudière et Keller, Mycotaxon 11: 331. 1980 (nec *C. major* (Thaxter) Remaudière et Keller in Keller, Sydowia 40: 132-134. 1987).

Hyphal bodies irregularly ameboid-vesiculose or oblong, of the approximate dimensions in outlines 50-80 x 18-45 µm; nuclei numerous (18-44) of the diameter 3.5-6 µm. Conidiophores unbranched, claviform or flask-shaped, the widest in subapical portion, 25-35 µm thick, attenuated conically into distinct conidium bearing neck. Primary conidia spherical to broadly pyriform, (38-) 47.5-52 (-58) x (32-) 40.5-47 (-55) µm containing 15-56 nuclei. Papillae semispherical, abruptly convex, about 18 µm wide and 10 µm long, often with fine spine in the centre of convexity. Rhizoids monohyphal, ribbon-like about 20-25 µm wide, with distinct round terminal expansions of jagged margins. Resting spores observed by Keller (1987) only in cultures, globose, 30-58 µm, unmentioned by Thaxter (1888), but reported from insects by Gustafsson (1965) as spherical, hyaline 51-74 µm in diam. (ca. 63 µm) and by Aruta and Carrillo (1989) as 42.3-62.6 µm in diam. (ca. 52.9-4.9 µm).

The fungus grew well on media enriched with egg yolk; the Polish strain from an ichneumonid developed well and sporulated on PDA and SDA, producing typical conidia of greater variability range.

Distribution and hosts. Hitherto reported from North and South America, Europe and Asia as a pathogen on several insect species of different orders: *Ptilodactyla serricollis* (Say) (*Coleoptera*), *Tipula* sp. (*Diptera*), *Myzodium modestum* (Hottes) (*Homoptera*).

Occurrence in Poland. Notecka Forest, on an adult of unidentified ichneumonid species (*Hymenoptera*) (Fig. 16), Białowieża National Park, on a big crane-fly, probably *Tipula* sp.

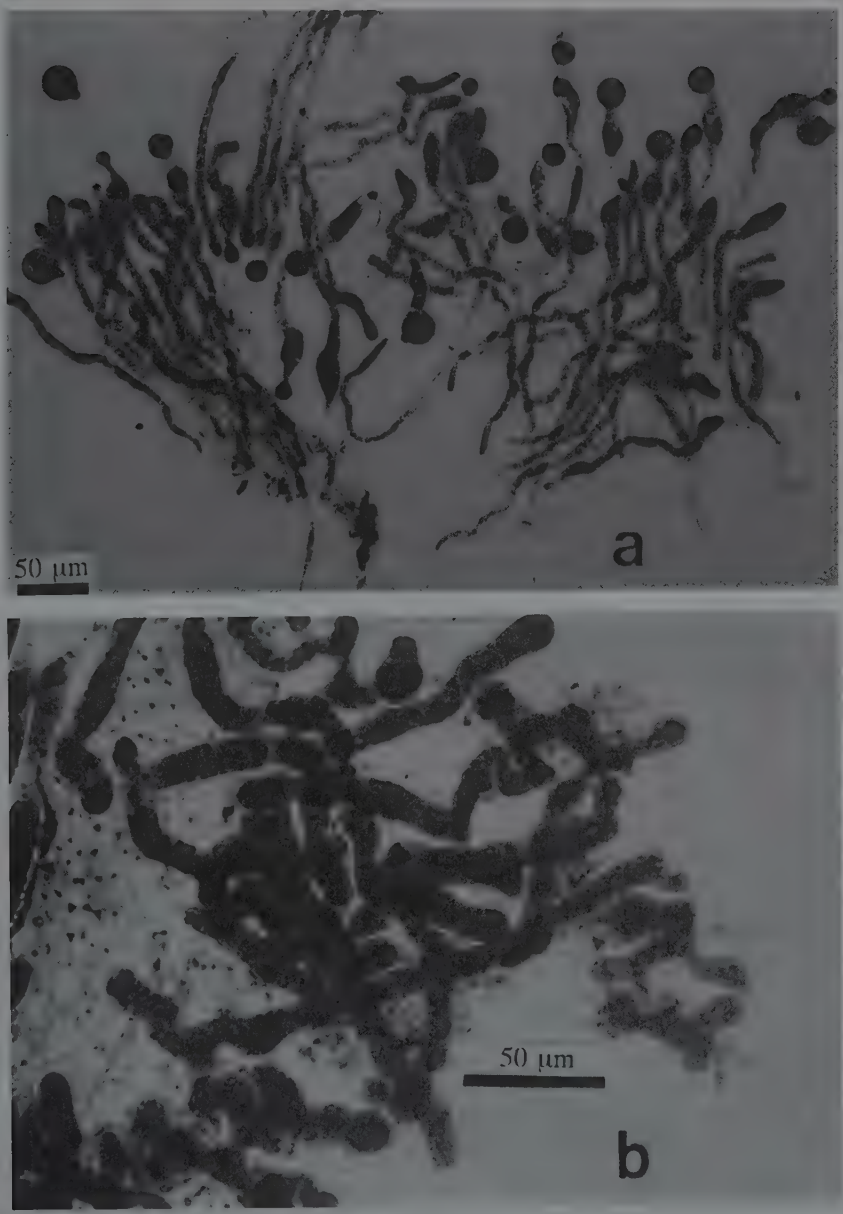


Fig. 16. *Batkoa major*: a — conidiophores and conidia, b — hyphal bodies and hyphae (from a species of *Ichneumonidae*, Notecka Forest).

Remarks. The author's stand point concerning the status of this species in analogous as that expressed in remarks on *Batkoa apiculata* (p. 109). The characteristic of *Entomophaga limoniae* given by Keller (1987: 146-148) has been purposefully chosen as a basis for the above description since it seems to be the fullest and most exact from all so far existing. Thaxter's (1888) descriptions contains very restricted data to serve as a base for identification of later collected materials whereas Humber's (1989: 447) supplement concerns only character of the nuclei. All descriptions of this species infecting tipulids show great similarity, except a little smaller resting spores reported by Aruta and Carrillo (1989) in relation to Gustafsson's (1965) measurements. The hyphal bodies in the Polish strain from an ichneumonid (Fig. 16b) were mostly irregularly elongate or at most slightly polymorphic-ameboid and those from the crane fly (Fig. 1e) differ considerably, corresponding perfectly with Keller's description of *E. limoniae*. These differences as well as wide host range of systematically remote insect species may idicate a complex character of this species. Keller (1991: 117) persists in his opinion that *Entomophaga limoniae* is a separate species.

5. *Batkoa papillata* (Thaxter) Humber

Batkoa papillata (Thaxter) Humber, Mycotaxon 34: 446. 1989; — *Empusa papillata* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 166-167. 1888; — *Entomophthora papillata* (Thaxter) Gustafsson, Lantbrukshogsk. Ann. 31: 130-131. 1965; — *Conidiobolus papillatus* (Thaxter) Remaudière et Keller, Mycotaxon 11: 331. 1980; — *Entomophaga papillata* (Thaxter) Keller, Sydowia 40: 148. 1987.

Hyphae tubular, strongly vacuolized, containing nuclei 2.5-4 µm in diam. Conidiophores unbranched; conidiogenous cells usually strongly distended in upper parts. Primary conidia broadly ovoid or pyriform (38-) 47-52 (-59) x (26-) 32.5-35.5 (-45) µm, about 50-80-nucleate, with very long, prominently protruding papillae of fully obtuse convexity. Secondary conidia smaller. Rhizoids monopyhal, rather stout, sometimes with short terminal branches; Keller (1987) reports them as without specialized holfasts, whereas in Thaxter's (1888) drawings such a structure has been illustrated (Pl. 15. fig. 84). Resting spores globose, 45-55 µm, with thick, smooth, slightly brownish epispore.

Distribution and hosts. North America, Europe, on small dipterans in moist habitats or floating on water surface.

Occurrence in Poland. Notecka Forest (Łąkie Lake), Wielkopolski National Park, mid-forest pond; in both cases on small floating nematocerous flies.

Genus *Completoria* Lohde

Completoria Lohde, Tagebl., Versamml. Gesellsch. Deutsch. Naturf. Ärtzte 47: 206. 1874.

Thallus develops as clusters of hyphal bodies filling host's cell. Conidiophores oligokaryotic, protruding externally from the hyphal bodies. Primary conidia uni-

tunicate, oligokaryotic, with papillate base, discharged by papilla eversion. Secondary conidia passively detached. Zygospores round, thick-walled, formed as a result of gametangiogamy in gametangial buds. Parasite in fern gametophytes. One species described.

(1). *Completoria complens* Lohde

Completoria complens Lohde, Tagebl. Versamml. Gesellsch. Deutsch. Naturf. Ärzte 47: 205-206. 1874; — Leitgeb, Sitzungsber. Akad. Wiss. Math.-Naturwiss. Cl., Abt. 1, 84: 288-324. 1881.

Mycelium develops in the host cells as clusters of lobate hyphae 15-30 x 7-17 µm from which conidiophores, 60-80 µm long, protrude. Primary conidia oligokaryotic unitunicate, pear-shaped, 15-25 µm long, with papillate base. Secondary conidia without discharge mechanism. Zygospores globose with smooth epispore 17-33 µm diam.

Distribution and hosts. Central Europe and USA, parasite in cells of fern gametophytes.

Remarks. Because of particular phytopathogenicity Humber (1989) proposed to establish a new monotypic family named *Completoriaceae*.

Genus *Entomophaga* Batko

Entomophaga Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 325-326. 1964, — Humber, Mycotaxon 13: 228. 1981; Mycotaxon 34: 447-448. 1989.

Mycelium inside infected hosts in form of round, ovoid ameboid or irregularly elongate hyphal bodies, deriving from filamentous, rather thick, hyphae. Nuclei entomophthoroid, several to several dozen in particular hyphal bodies, conidiophores and conidia. Conidiophores unbranched, porotruding singly from hyphal bodies as equally narrow hyphae perforating post mortem host's cuticle and forming terminal, somewhat inflated, bottle-shaped or clavate conidiogenous cells, separated by a cross-wall from the maternal, empty hyphae. Conidia unitunicate, usually pear-shaped or subglobose with obtuse, blunt and rather coarse papillae, ejected by papilla eversion. Secondary conidia of the same type and similar or elongate and probably non-adhesive, formed on tubular secondary sporophores with rudimental mechanism of ejection. Resting spores azygospores formed extracellularly from particular hyphal bodies, typically spherical or subspherical, rarely and only single ovoid or ellipsoid. In the species known till the present rhizoids absent. Monophagous or oligophagous pathogens of insects and harvest

spiders, highly specialized as regards species and development instar of hosts. Hardly distinguishable species affecting grasshoppers and caterpillars, originally described as *„Entomophthora grylli"* Fresenius and *„Empusa aulice"* Reihardt in Bail respectively, were historically regarded either as the same species (Thaxter 1888, Gustafsson 1965) or as two different ones, eventually each represented by a series of different pathotypes. Lately (Soper et al. 1983,. Humber 1984; Humber & Soper 1986) both aforementioned taxa are considered to be complex species from which new species were emerged on the basis of some physiological and biochemical differences, manifesting in the nature by very close pathogenic relation to definite host species and its phase of development.

In the majority of earlier paper — generally till 1980 — the species with the above characteristics were treated as representatives of the genus *Empusa* ss. Nowakowski (1883) or *Entomophthora* s.l., whereas Remaudière and Keller (1980) included them to *Conidiobolus.* Batko (1964a, 1974) tried to distinguish *Conidiobolus* and *Entomophaga* strains on the basis of some trophic relations — saprophytism or facultative zoopathogenicity in the first versus arthropod parasitism in the second — but such a view is no longer tenable. Easily staining entomophthoroid nuclei of *Entomophaga* allow to differentiate these taxa (Humber 1981, 1989; Keller 1987). Humber (1989) listed 10 species under this generic name. Keller (1991) has not accepted Humber's genus *Batkoa* treating this subdivision as premature. In this review the genera *Entomophaga* and *Batkoa* have been treated as separate. Regarding *Entomophaga aulicae* and *E. grylli* as complex species and omitting some American, Asiatic and Australian species mentioned by Soper and Humber (1984) 14 species have been recognized here, including two new ones. Both complex species and six other distinctly separable were found in Poland.

Key to species

1. Primary conidia small, 15-31 x 12-25 µm; resting spores 12-25 µm in diam. 2
1*. Primary conidia distinctly greater, the smallest usually over 25 µm long; resting spores much greater or unknown 3

2. Primary conidia rather ovoid, 17-18 x 12-14 µm; resting spores hyaline, subglobose, about 21 µm in diam., on caterpillars *E. saccharina*, p. 123
2*. Primary conidia pyriform, 15-31 x 12-25 µm, with markedly long overpapillar neck; resting spores 12-25 µm in diam., on aphids . . . . . *E. pyriformis*, p. 119

3. Pathogens of harvest spiders; primary conidia about 43-52 x 30-37 µm . . . . . *E. batkoi*, p. 128
3*. Pathogens of insects 4
4. On adult diptera 5
4*. On other insects or their larvae 8
5. Conidial sporulation begins on living insects often with tearing off abdominal segments; on calyptrate flies . . . . . *E. kansana*, p. 119
5*. Conidial sporulation on dead insects with abdominal segments sometimes ruptured but not disjoining 6
6. On tabanids; primary conidia 36.7±3.5 x 32.4±3.2 µm, typically 15 nucleate . . . . . *E. tabanivora*, p. 125
6*. On nematocerous flies or gnats 7
7. Primary conidia (30-) 41-48 (-61) x (21-)30-34 (-46) µm, 11-36-nucleate; only common type of secondary conidia occurs; on small gnats just above water surface or floating . . . . . *E. conglomerata*, p. 119
7*. Primary conidia 36-43 (-47) x 23-26 (-27.3) µm, 8-28-nucleate; common and elongate secondary conidia occur; on tipulid and limnobiid adults in deciduous forest undergrowth . . . . . *E. tipulae*, p. 123
8. Primary conidia 12-18 nucleate, ovoid to turbinate, 35-43 x 24-30 µm with small papillae, not wider than 1/3 of the maximal conidium diameter; on adult beetle *Lagria hirta* L. (*Coleoptera*: *Lagriidae*) . . . . . *E. lagriae*, p. 121
8*. Primary conidia contain from a dozen to several dozen nuclei, pyriform, with papillae usually as wide as a half of conidium diameter; on other insects 9
9. Primary conidia 27-40 (-47.5) x (18-) 20-35 (-40) µm; resting spores regularly globose with dark yellow to brown epispore, 30-45 µm in diam.; on grasshoppers or caterpillars 10
9*. Primary conidia generally greater, 40-56 x 35-43 µm; resting spores hyaline, mostly over 50 µm in diam; on tenthredinid larvae (*Hymenoptera*: *Symphyta*), exceptionally also on adults 13
10. On caterpillars; hyphal bodies rounded or irregularly elongate 11
10*. On locust or grasshoppers (*Orthoptera*); hyphal bodies spherical, subovoid or of less regular rounded shapes 12
11. Primary conidia 10-15 nucleate, (24-) 29.5-32.5 (-44) x (17-) 20-22 (-30) µm or close to . . . . . *E. aulice*, (complex species), p. 117
11*. Primary conidia 21-34, (av. 26) nucleate, 20-36 x 16-28 µm (ca 26.1 +1.1 x 20.6 +1.0 µm); on lymantriid caterpillars . . . . *E. maimaiga*, p. 118

12. Pathogens of *Melanoplus* spp. (*Orthoptera*: *Acridiidae*) hardly producing conidia both in nature and in cultures . . . . . *E. calopteni*, p. 117
12*. Pathogens of other grasshoppers, easaily producing both conidia and resting spores . . . . . *E. grylli*, (complex species), p. 116
13. Resting spores mainly regularly globose 45-60 (-66) µm in diam., of walls 2.5-3 µm thick; in tenthredinid larvae on herbaceous and deciduous plants . . . . . *E. tenthredinis*, p. 126
13*. Resting spores mostly subglobose, 45-75 (-90) µm in diam., or ovoid to ellipsoid, often with marked basal convexities, 50-85 x 45-65 µm, with walls 5.5-7.5 µm thick; on larvae of *Diprionidae* mostly in cocoons on coniferous trees *E. diprionis*, p. 126

1. *Entomophaga grylli* (Fres.) Batko

Entomophaga grylli (Fres.) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 325. 1964. — *Entomophthora grylli* Fresenius, Bot. Ztg. (Berlin), 14: 882-883. 1856. — *Conidiobolus grylli* (Fres.) Remaudière et Keller, Mycotaxon 11: 330-331. 1980;
Entomophthora colorata Sorokin, Zap. Imp. Akad. Nauk, 37: 62-66 1881.

Hyphal bodies subglobose 12-38 µm in diam., 1-18-nucleate, ovoid or somewhat ameboid, 33-68 x 22-50 µm in outline, 4-24-nucleate, develop from nearly spherical protoplasts. Conidiogenous cells clavate, 70-105 x 18-20 µm. Primary conidia pear-shaped of the dimension range after different references (MacLeod & Müller-Kögler 1973: 853) 25-45 x 17.5-37 µm, in the author's original materials from Poland 30-38 (-39.8) x 26.5-32 µm, 18-22-nucleate. Secondary conidia of the same type in subsequent series gradually smaller and smaller. Azygospores globose, 38-42 µm in diam., smooth of the wall brown up to 4 µm thick, formed extracellularly from the hyphal bodies by direct budding. Infected insects affixed to top parts of herbaceous plants by contraction of legs.

Distribution and hosts. All continents except Antarctide mainly in grassland and semi-desert regions, on different orthopteran species mostly of the family *Acridiidae*.

Occurrence in Poland. Wolin Island, Notecka Forest, Wielkopolski National Park, Lublin Upland; probably common all over the Country. Identified hosts in Poland. *Chorthippus brunneus* (Thunberg). *Ch. albomarginatus* (Degeer), *Ch. mollis* (Charp.), *Ch. biguttatus* (L.), *Ch. dorsatus* (Zetterstedt), *Myrmeleotettix maculatus* (Thunberg).

Remarks. *E. grylli* is recently considered to be a complex species, with respect to the morphology very close to *E. aulice* (Reichardt in Bail) Humber, differing, however, by isoenzyme patterns (Humber 1984) and obvious host specificity.
According to American authors' opinion there are at least two pathotypes in *E. grylli* differring by development rate and ability to produce the primary conidia and resting spores. The name *E. mac-*

leodii Humber has been applied for the pathotype I of *E. grylli* (Soper et al. 1983) easily producing conidia on infected hosts whereas resting spores occurred only on some individuals (Soper & Humber 1986). Humber (1989) has proposed to apply the name *Entomophaga calopteni* (Bessey) Humber for the pathotype II, hardly produced conidia and infecting commonly species of the genus *Melanoplus* [also originally described from *Melanoplus differrentialis* (Thomas), syn. *Caloptenus differentialis* (Thomas)]. Other species separated from this complex are *E. asiatica* Humber, Soper et Shimazu from Japan and *E. praxibuli* Humber, Milner et Soper from Australia (Soper & Humber 1984). Other materials including Polish ones here referred, require supplementary investigations to establish their real systematic affiliation and diversity range.

(2.) *Entomophaga calopteni* (Bessey) Humber

Entomophaga calopteni (Bessey) Humber, Mycotaxon 34: 447. 1989; — *Entomophthora calopteni* Bessey, Amer. Natur. 17: 1280. 1883; *Entomophthora* (*Tarichium*) *calopteni* Bessey ex MacLeod et Müller-Kögler, Mycologia 62: 42-43. 1970.

Vegetative growth in form of round or somewhat ameboid protoplasts transferring into subglobose or ovoid hyphal bodies not different from those of *E. grylli*. Conidial sporulation not occurring under common conditions. Azygospores clay coloured in mass, globose, 36-39 µm in diam., some of them of not regularly round outline; protoplasm granular with one large round vacuole. Walls up to 4 µm thick with somewhat yellow superficial layer.

Distribution and hosts. North America, in *Melanoplus differentialis* (Thomas).

Remarks. See *E. grylli*.

3. *Entomophaga aulicae* (Reichardt in Bail) Humber

Entomophaga aulice (Reichardt in Bail) Humber, Mycotaxon 21: 270. 1984; — *Empusa aulice* Reichardt in Bail, Schrift. Naturf. Gesellsch. Danzig, n. Ser. 2 (2): 3. 1869; — *Entomophthora aulice* (Reichardt in Bail) Sorokin, Hedwigia 15: 148. 1876; — *Empusa anticae* Reichardt ex Mitchell, Entomol. News 30: 193.1919.

Empusa elegans Majmone, Centralbl. Bakteriol., 2 Abt. 40: 107. 1914; — *Entomophthora egressa* MacLeod et Tyrrell in Otvos, MacLeod et Tyrrell, Canad.Entomol. 105: 1436. 1973.

Hyphal bodies subglobose, 22.5-27.5 µm in diam., or ovoid 27-35 (-45) x 21.5-27 µm, germinating usually with one hypha 6.8-11.5 µm thick, unbranched and terminated on host's surface by bottle-shaped or somewhat clavate conidigenous cell 40-95 x 15-21.5 (-23.5) µm. Primary conidia as reported in references 29-38 x 20-30 µm, pyriform and obovoid, with distinctly protruded, broad, obtuse papilla. In the author's materials there were two different enough forms of the primary

conidia. On *Euproctis chrysorrhoea* (L.) from Poland and an unidentified lymantriid caterpillars from Nepal they were regularly pear-shaped of the dimensions rather very stable, (28-) 31-34 (-35.3) x 20.5-22.8 μm, with distinctly semispherical papillae 10.5-12 μm broad and 5.5-6.5 μm long. On *Panolis flammea* (S c h i f f.) and some other noctuid and geometrid caterpillars the primary conidia were rather ovoid to broadly ovoid, somewhat greater, (31.5-) 34-37.5 (-42) x (-21.5) 23-26 (-27.5) μm, with papillae 12-14 μm wide and about 4 μm long, smoothly merged with the conidium outline; in both cases the numbers of nuclei were mostly 12-14. Resting spores found only in materials from *E. chrysorrhoeea*, were globose (42-) 44-55 (-59) μm in diam., with walls 4-4.8 μm thick, of smooth, sligtly brownish epispore.

D i s t r i b u t i o n a n d h o s t s. The world over, on caterpillars of some species of the families *Arctiidae*, *Geometridae*, *Lymantridae*, *Noctuidae*, *Pyralidae* and *Tortricidae*. The author obtained abundant material on lymantrid caterpillars from Nepal collected in April 1987 (leg. B. Dembowska) which seems to be very close to *E. maimaiga* (see next description).

O c c u r r e n c e i n P o l a n d. Pomerania, Silesia, central Poland, Masovian region; probably common in all the country. The fungus causes often heavy epizootics in populations of *P. flammea*, *E. chrysorrhoea* and other species during their gradations.

R e m a r k s. According to the recent papers concerning taxonomy of the entomophthorales *E. aulicae* should be treated as a complex taxon from which the species *E. maimaiga* H u m b e r, S h i m a z u et S o p e r has been separated (S o p e r et al. 1988), whereas the majority of similar collections have been identified in routine way as *E. aulicae* or remain undetermined (K u s h i d a & K a t a g i r i 1975). In some important monographs or papers (T h a x t e r 1888, R i d d l e, 1906, G u s t a f s s o n 1965) *E. aulicae* has been treated as identical with *E. grylli*. Intraspecific taxonomy of these species complexes requires further detailed studies.

(4). *Entomophaga maimaiga* H u m b e r, S h i m a z u et S o p e r

Entomophaga maimaiga H u m b e r, S h i m a z u et S o p e r in S o p e r, et al., J. Invertebr. Pathol. 51: 229-241. 1988.

Vegetative growth as ameboid and fusoid protoplasts or bead-like chains of cells in host hemolyph, transforming into hyphal bodies giving rise normal, sparsely septate hyphae. Conidiophores unbranched; conidiogenous cells almost cylindric or slightly clavate, 98-175 x 16-24 μm. Primary conidia pyriform, hyaline or light yellowish, 20.5-35.5 x 15.8-27.6 μm (av. 26.1 ±1,1 x 20.6 ±1 μm), 21-34-nucleate (av.26), with great, round vacuole in the centre. Papillae broadly obtuse of semiglobular convexity, about half so broad as the greatest conidium diameter. Resting spores spherical 20-40 μm in diam., (av. about 32 μm) with 0.6-4 μm thick walls, formed as azygospores

Distribution and hosts. Eastern and South-Eastern Asia on caterpillars of *Lymantria dispar* (L.) (*Lepidoptera*: *Lymantriidae*), experimentally also infects caterpillers of North American lymantrid caterpillars of *Orgyia pseudotsugata* McDunnough and in very low degree (*Heliothis zea* (Boddie) (=*Heliothis armigera* Hübner), *Trichoplusia ni* (Hübner) (*Lepidoptera*: *Noctuidae*) and *Estigmene acrea* (Drury) (*Lepidoptera*: *Arctiidae*).

5. *Entomophaga conglomerata* (Sorokin) Keller

Entomophaga conglomerata (Sorokin) Keller, Sydowia 40: 140-141.1987; — *Entomophthora conglomerata* Sorokin, Beitr. Biol. Pflanzen.2: 388-393. 1877; — *Empusa conglomerata* (Sorokin) Brumpt, Ann. Parasitol. Hum. Comp. 18: 124-127. 1941; — *Conidiobolus conglomeratus* (Sorokin) Remaudière et Keller, Mycotaxon 11: 330. 1980.

Hyphal bodies rounded-ovoid or somewhat ameboid, 18-67 x 14-34 µm, 10-50-nucleate. Conidiogenous cells clavate, 60-110 x 18-22.5 µm. Primary conidia 10-35, most frequently 22-26-nucleate, broadly pear-shaped, (30-) 40-48 (-60) x (20-) 29-35 (-45) µm with broad, obtuse, rather abruptly protruded papillae. Secondary conidia of the same type. Resting spores unknown. Rhizoids mentioned by Keller (1987: 138) but not described nor illustrated. All specimens investigated by the author were floating on water surface and there have not been observed differentiated hyphae of the character of rhizoids.

Distribution and hosts. Europe; adults of *Culex* spp. and possibly other species of the families *Culicidae*, *Chironom idae* and *Tipulidae*.

Occurrence in Poland. Wielkopolski National Park — small ponds in forest reserves, Łąkie Lake in the Notecka Forest (Western Poland). The fungus from adult dipterans found by Nowakowski (1883) in the Warsaw Botanical Garden and determined as „*Entomophthora grylli* Fresenius" is supposed to be *E. conglomerata*. Unfortunately, any preserved materials have not been found.

Remarks. See *Entomophaga tipulae* (p. 125).

(6). *Entomophaga pyriformis* (Thoizon) Bałazy, n. comb.

Entomophthora pyriformis Thoizon, Entomophaga 12: 303–307. 1967 (basionym).

Hyphal bodies elongate with outgrowths or branches. Primary conidia pyriform, 15–31 x 12–25 m (av. 25–19 m), 20–30-nucleate. Secondary conidia pyriform to subglobose, little smaller than the primary ones. Resting spores globose, smooth, colourless, 12–25 m diam. Infected hosts at first brown-red, transcolouring gradually in brown-yellow at the development of conidiation.

Distribution and hosts. France and Russia, on aphids *Rhopalosiphum insertum* (Walk.), experimentally also infecting *R. padi* (L.) and *Sitobion avenae* (Fabr).

7. *Entomophaga kansana* (Hutchison) Batko

Entomophaga kansana (Hutchison) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 404. 1964. — *Entomophthora kansana* Hutchison, Mycologia 54: 263-264. 1962.

Hyphal bodies spherical, about 30-60-nucleate, rarely ovoid or ellipsoid, 33-63 x 23-39 μm, germinate with one hypha 9-11.5 μm thick or form azygospores by

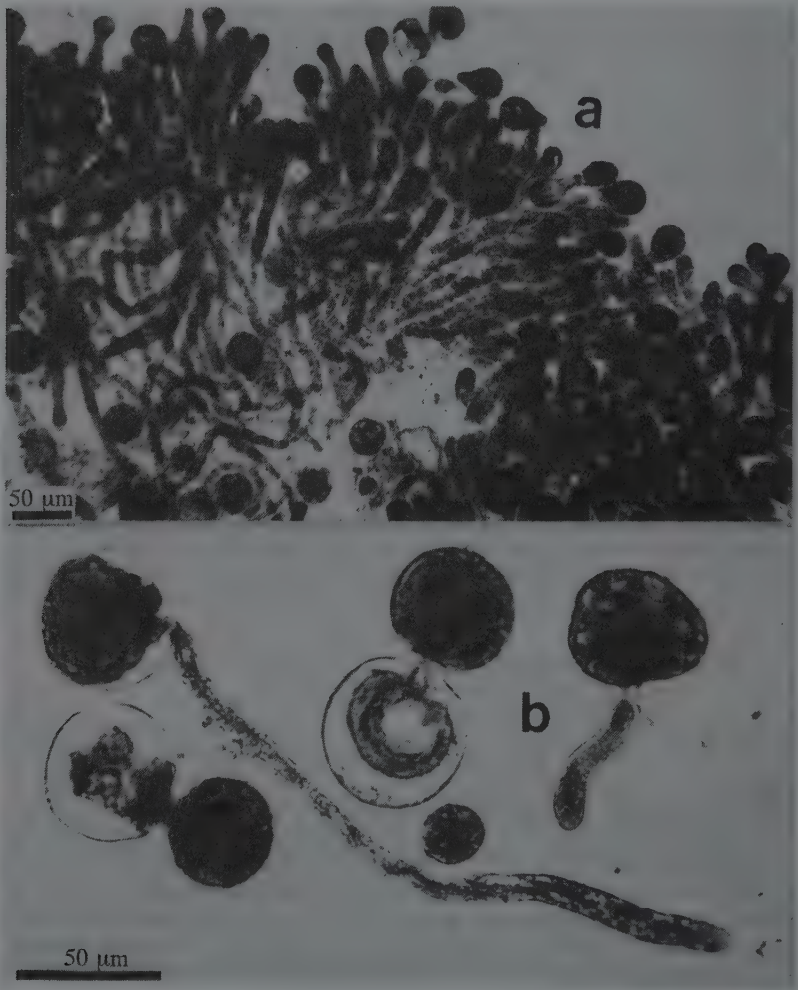


Fig. 17. *Entomophaga kansana*: a — conidiophores and conidia, b — round hyphal bodies germinating by hyphae and transforming into azygospores; (from a calliphorid fly, Wielkopolski National Park).

direct budding (Fig. 17b). Sporogenous cells 62-132 µm long, distinctly clavate widened in top part up to 22-27 µm and attenuated steadily at tips forming a moderately long neck. Primary conidia about 35-40-nucleate, typically pear-shaped, distinctly papillate, 38.8-45.6 (-46.9) x 28.5-36.5 µm, with papillae 12.5-14.8 x 8-9 µm; overpapillar neck short but distinct, 1.5-2.5 µm long (Fig. 17a). Seconadry conidia reported by Hutchison (1962) as ovoid with truncate base 24-31 x 15-24 µm, but in Polish material they are of the same shape as the primary ones. The conidiation begins to appear on living flies crawling on moist surface close to water, often with partially destroyed abdomens. Rhizoids lacking — host's cadavers usually affixed to substrate by some fungus exudate. Resting spores globose, (38.5-) 40-46 (-49) µm in diam., of the wall smooth 2.5-3.5 µm thick, superficially somewhat smoky derkened.

Distribution and hosts. United States of America and Central Europe, in some species of calyptrate flies (*Calliphoridae*, *Sarcophagidae*, *Muscidae* and *Tachinidae*), in moist places.

Occurrence in Poland. Wielkopolski National Park, protective distr. Jeziory and Puszczykowo, at a brook and seasonal pools in hardwood forests, in August 1986, 1989, 1991-1993 in big blue-bottle flies (*Calliphoridae*).

Remark. Despite the lack of truncate secondary conidia the peculiar behaviour of infected insects allow to identify this species. In one case a fly was infected by this fungus and *Zoophthora ovispora* (Fig. 23b).

(8.) *Entomophaga lagriae* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia 7-15-nucleata, subglobosa, diametro 28-35 µm, vel ovali-ellipsoidalia usque ad 80 µm longa, 15-20 µm crassa. Hyphae 9-10 µm crassae, plerumque singulae, raro binae e corporibus hyphalis excrescunt. Cellulae conidiogenae clavatae, dimensionibus 65-102 x 16-21 µm. Conidia primaria 12-18-nucleata, ovoidea vel late turbinata cum parte terminali regulariter semiglobosa, dimensionibus 35-43 x 24-30 µm; papillae conicae vel obtusae, 9.5-11 µm latae. Conidia secundaria primariis similia, dimensionibus minimis 28.5 x 20 µm, cum papillis indistinctis, circa 8 µm latis. Sporae perdurantes ignotae. Fungus entomogenus in imagine Coleopteri Lagria hirta L. parasitans.*

Holotypus. *Specimen numero 1944 in collectione* ZBS PAN *designatum, die 9 mensis Augusti, anno 1987 in vallo rivi* Paschiavo *(Alpes Helvetici) prope* Chur-Deanos *collectum (*leg. W. Szwed*).*

Hyphal bodies 7-15-nucleate, subspherical 28-35 µm in diam. or irregularly ovoid to ellipsoid up to 80 x 15-20 µm; hyphae 9-10 µm thick protrude singly or in twos from particular hyphal bodies. Conidiophores unbranched; conidiogenous cells claviform 65-102 x 16-19.5 (-21) µm. Primary conidia 12-18-nucleate, ovoid or broadly turbinate with regularly semispherically rounded top parts, 35-43 x 24-30 µm, and papillae narrow conical or somewhat obtuse, 9-11.5 µm wide. Second-

Fig. 18. *Entomophaga lagriae*: a — hyphal bodies, b — primary conidia, b'-a primary conidium germinating by two hyphae, c — contours of secondary conidia (from the beetle *Lagria hirta,* Paschiavo, Switzerland).

ary conidia of the first series of similar shapes, in subsequent series more and more ovoid to ellipsoid of weakly marked papillae, the smallest 28.5 x 20.5 µm with about 8 µm wide papillae. Resting spores unknown. (Fig. 18).

Distribution and host. On the beetle *Lagria hirta* L. (*Coleoptera*: *Lagriidae*) attached to a grass by contraction of legs; subalpine spruce forest (*Calamagrostio villosae-Piceetum*), Paschiavo valley, 1650 m over sea level, Switzerland, 9 August, 1987 (leg. Dr.W. Szwed). Dry insect and prepared microscopical slides Nr. 1944 in collection ZBS PAN designed as the holotype.

Etymology: *Lagria* — generic name of the host species.

(9). *Entomophaga saccharina* (Giard) Batko

Entomophaga saccharina (Giard) Batko, Bull. Acad. Pol. Sci., Ser.Sci.Biol. 12: 404. 1964; — *Entomophthora saccharina* Giard, Comp. Rend. Hebd. Seanc. Mem. Soc. Biol. 40: 786. 1988; — Bull. Sci. France Belgique 20: 198-202. 1889; — *Empusa saccharina* Giard ex Lakon, Z. angew. Entomol. 5: 173. 1919.

Hyphae from host's body cavity 7-10 µm thick. Conidiophores unbranched. Primary conidia pyriform of generally globose outline, attenuated towards the base into distinct elongation closed by arcuate papillae; their measurements 17-18 x 12-14 µm. Resting spores irregularly globose or ovoid, of the mean diameter 21 µm, originating as azygospores on hyphae or close to junctions of hyphae suggesting conjugation; their walls are smooth, according to Giard's (Giard 1889: 199 and pl. III, fig. 5) figures about 2.5-3 µm thick; colour of caterpillars filled with these resting spores indicates some dark pigment in the epispore.

Distribution and host. France, on caterpillars of *Euchelia jacobeae* (L.) (*Lepidoptera*: *Arctiidae*). Known only from the type locality.

10. *Entomophaga tipulae* (Fresenius) Humber

Entomophaga tipulae (Fresenius) Humber, Mycotaxon 34: 448. 1989; — *Entomophthora tipulae* Fresenius, Abhandl. Senckenb. Naturf. Gesellsch. 2: 206. 1858 [nec *Entomophthora* (*Tarichium*) *tipulae* (Porter) MacLeod et Müller-Kögler, Mycologia 62: 54. 1970. basionym *Massospora tipulae* Porter. J. Elisha Mitchell Sci. Soc. 58: 65-68. 1942; see *Tarichium porteri* (Soper) Bałazy p. 263].

Protoplasts round to ovoid, some 10 to 25 µm in diam., becoming ovoid, ellipsoid or elongate hyphal bodies 32-60 x 17-25 µm, 1 to about 25-nucleate, often with single outgrowts. Hyphae almost paralellepipedous 9.5-15 µm thick, usually unbranched, separated by pseudosepta from segments devoid of protoplasm. Nuclei ovoid 5.5-7 x 4-5.5 µm linearly arranged, in thicker segments less regularly. Conidiophores unbranched. Conidiogenous cells somewhat clavate, 100-120 µm

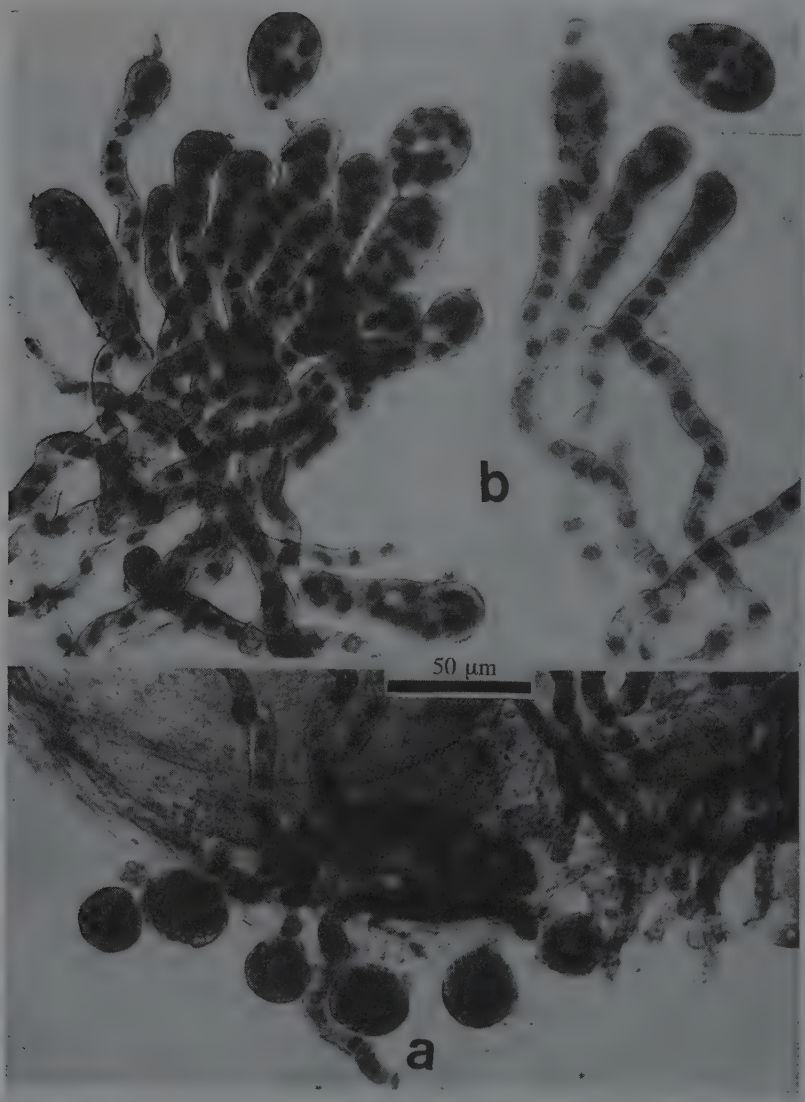


Fig. 19. *Entomophaga tipulae*: a — round hyphal bodies and hyphae, b — conidiophores and conidia (from specimens of *Limoniidae*, Białowieża National Park).

long, 7.5-12 µm thick in lower part and gradually widened to 12-20 µm towards the tip. Primary conidia 12-25-nucleate ovoid, (32-) 36.5-43 (-46.8) x 23.5-25.5 (-27.3) µm, with distinctly marked semiglobose papillae about 10 µm long and 12-14 µm wide. Secondary conidia of two types. The first similar to the primary ones but gradually smaller and smaller, the second — non-adhesive, elongate, bipolarly symmetric conidia of somewhat thicker wall, 47-64 x 11-15 µm, containing 6-12 nuclei and one to three round vacuoles situated in the widest central part (Fig. 8i), produced on short, tubular sporophores about 10-15 µm wide, terminated with rudimentary and non functioning papillar structure. Resting spores light yellow, spherical, (34-) 37.5-52.5 (-59) µm in diam., of the walls 2.3-2.8 µm thick with smooth epispore. Host's cadavers mostly attached to leaves and thin branches by contraction of legs or in normal position on the underside of leaves of shrubs in the forest undegrowth. (Fig. 19).

Distribution and hosts. Central Europe, on adults of *Tipulidae* and *Limoniidae*, in deciduous forests.

Occurrence in Poland. Wielkopolski and Białowieża National Parks, very common in late spring (third decade of May and June); other localities not investigated.

Remarks. Humber (1989: 448) seems to treat the name *Entomophthora thaxteri* Brumpt (1940) (see also Brumpt 1941) as a synomym of *E. tipulae*, whereas MacLeod and Müller-Kögler (1973) discussed rather — following Brumpt (1941) and Gustafsson (1965) — possible identity of the former with *Entomophaga conglomerata* (Sorokin) Keller. In face of very great morphological resemblance of different species of *Entomophaga* this problem requires further detailed studies. Apart from slightly smaller primary conidia in *E. tipulae*, different habitat conditions between the author's collections identified as *E. tipulae* and *E. conglomerata* and the occurence of elongate secondary conidia in the former the author is not able to indicate any other differences at the moment.

(11.) *Entomophaga tabanivora* (Anderson et Magnarelli) Humber

Entomophthora tabanivora (Anderson et Magnarelli) Humber, Mycotaxon 21: 270. 1984; — *Entomophthora tabanivora* Anderson et Magnarelli, J. Invertebr. Pathol. 34: 263-266. 1979.

Hyphal bodies ameboid or irregularly elongate 54.8 ±16.9 x 15.3 ±2.4 µm in diam. of outlines. Conidiophores unbranched; conidiogenous cells clavate 89.1 ±11.7 x 18.9 ±1.9 µm, cream coloured in mass, occurring in all membraneous sutures of host's body. Primary conidia 36.7 ±3.5 x 32.4 ±3.2 µm, containing about 15 nuclei and 3-6 large oil droplets. Resting spores unknown.

Distribution and hosts. United States of America, on adult of *Tabanus nigrovittatus* Zett. and *Atylotys thoracicus* (Heine) (*Diptera*: *Tabanidae*).

12. *Entomophaga tenthredinis* (Fres.) Batko

Entomophaga tenthredinis (Fres.) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 404. 1964; — *Entomophthora tenthredinis* Fresenius, Abh. Senckenberg. Naturf. Gesellsch. 2: 205. 1858. — *Empusa tenthredinis* (Fres.) Thaxter, Mem. Boston Soc. Nat. Hist. 4: 162. 1888; *Entomophaga tenthredinis* (Fres.) Batko; *Conidiobolus tenthredinis* (Fres.) Remaudière et Keller, Mycotaxon 11: 331. 1980.

Hyphal bodies ovoid, elongate or somewhat amoeboid, branched, 50-120 x 10-22 µm; longer. poorly branched hyphae of the diameter about 20 µm often present inside host's body. Conidiophores unbranched with clavate terminal conidiogenous cell 70-110 x 19-27 µm. Nuclei in the hyphae and conidiophores linearly arranged in numbers of about 15 to 70. Primary conidia some 30 to 70-nucleate, oblong pyriform, (41-) 45-52.5(-57) x (30-) 31-41 (-45) µm, with relatively broad obtuse papillae often concav in the center, about 9 µm long and 13-18 µm wide at the base. Secondary conidia of the same type, gradually smaller and smaller in consecutive series. Resting spores azygospores regularly globose (45-) 52-58 (-70.5) µm, seldom subglobose of the same greater diameter, with walls 2.5-3.5 µm thick, formed from the hyphal bodies by direct budding (Fig. 20).

Distribution and hosts. Europe, Asia, North America, in tenthredinid larvae on herbaceous plants and deciduous trees and shrubs.

Occurrence in Poland. Overall in fields, meadows and forest clearings from the third decade of June to August, especially frequent in neighbouring of lakes, pools, rivers and peatbogs. Identified hosts: *Dolerus* spp., *Strongylogaster lineata* Erichson; in one case dead specimen of adult *Selandria* sp. affected by this fungus was found together with its numerous larvae attached to grasses in a meadow of Turew (Park).

Records of Świeżyńska and Górnaś (1976) from *Diprion simile* Hartig have been based on erroneous identification by S. Bałazy. They concern the species *Entomophaga diprionis* Bałazy (see below). One cannot exclude a possibility that *E. tenthredinis* is a complex species. However, suggestion on synonymy of this species and *Tarichium cimbicis* (Bubák) Lakon (Petch 1944) appeared groundless.

13. *Entomophaga diprionis* Bałazy, n. sp.

Diagnosis. *Hyphae intra hospitum mortuorum corpus dense contextae, 22-27 µm crassae, cum multis brevibus ramis et appendicibus. Hyphae superficiales aequo-angustae, paulum ramosae, 12-20 µm crassae. Conidia primaria circa 50-70-nucleata, late piriformia, dimensionibus 41-56 x (34-) 36-43.5(-47) µm vel subglobosa diametro 41-55 µm, cum papillis 7-11 µm longis, 15-18 µm latis. Conidia secundaria minora. Sporae perdurantes globosae vel subglobosae, diametro (50-)55-73(-83) µm, ovatae vel breviter ellipsoidales, dimensionibus 53-75 (-86) x 46-76 µm, raro elongatae vel polymorphae 70-105 x 50-70 µm, hyalinae vel flavae, e hyphis ut azygosporae inter hyphae segmenta vel terminaliter excres-*

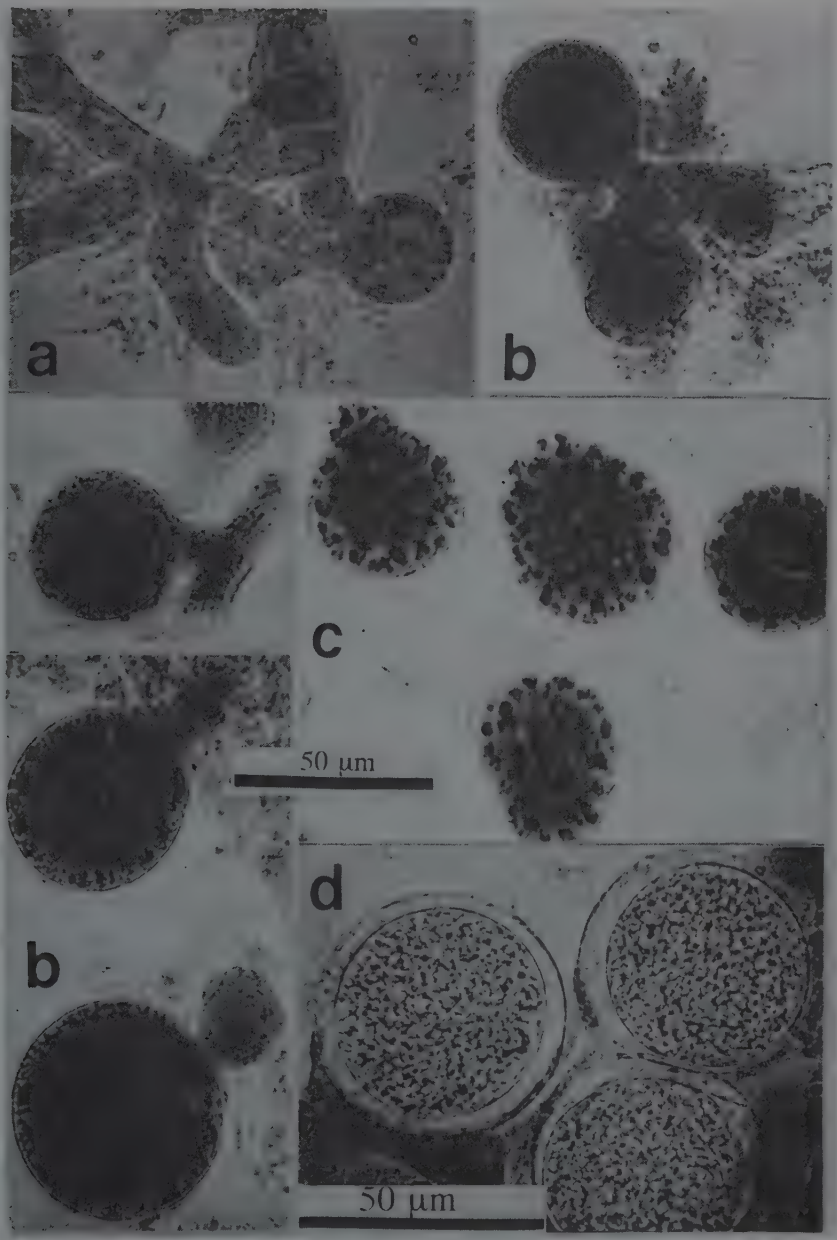


Fig. 20. *Entomophaga tenthredinis* — successive stages of azygospore formation: a — hyphal body, b — early stage of azygospore budding, c — young polykaryotic azygospores, d — ripening azygospores (from tenthredinid larvae, Wielkopolski National Park).

cunt; paries 5,5-7,5 µm crassus, episporium leve. Fungus in larvis Diprionis similis (Hymenoptera: Diprionidae) parasitans.

Holotypus. *Specimen numero 2072 in collectione* ZBS PAN *designatum, die 18 mensis Novembris anno 1974 in silva conifera* Krusza *prope* Nowogród *(Polonia) collectum.*

Mycelium filling host's body densely interwoven, thickly filamentous and richly irregularly branched, with sparse cross-walls, causes strong mummification of infected individuals. Hyphae of rather uniform diameter 22-25 (-27.5) µm with numerous short branches or outgrowths often suggesting conjugation in points of junction. Conidiophores unbranched with clavate terminal conidiogenous cells, 130-190 x 22-27 µm, separated always by the cross-wall from the parental equally narrow hyphae. Primary conidia 50-70 nucleate, broadly pyriform 41-56 x (34-) 36.5-43.5 (-47) µm, or almost globose 41-55 µm in diam., with abruptly protruding obtuse papillae 7-11 µm long and 15-18 µm wide at the base. Secondary conidia of the same type. Resting spores light yellow, globose or subglobose (50-)55-75(-83) µm in diam., ovoid or short ellipsoid 53-75 (-86) x 46-76 µm, rarely elongate or somewhat polymorphic about 70-105 x 50-70 µm in outline, surrounded by walls 5.5-7.5 µm thick of smooth epispore (Fig. 21), formed terminally, laterally and intercalerly on hyphae and their branches both inside the host body and in superficial mycelium. Their content is thickly and unevenly vacuolate and the nuclei do not stain in aceto-orcein or in aceto-carmine. Rhizoids absent, although numerous superficial hypahe are interwoven with network of silky webb of the inner layer of host's coccoon.

Distribution and host. In larvae of *Diprion simile* Hartig in cocconos collected in Scots pine forest litter during late autumn (end of October and November) in several localities in the Polish Lowland: Forest distr. Gniewkowo, Dobrzejowice and Solec Kujawski near Toruń. In all cases heavy epizootics occurred in the pine sawfly larvae during gradations. The life cycle during the whole vegetation period has not hitherto been recognized. Distribution, life history and economic significance require further studies.

Remarks. Probably the same species reported under the name *Entomophthora tenthredinis* Fresenius was found and thoroughly investigated in USA by Klein and Coppel (1973).

Etymology: *Diprion* — generic name of the host species.

14. *Entomophaga batkoi* (Bałazy) Keller

Entomophaga batkoi (Bałazy) Keller, Sydowia 40: 138. 1987; — *Entomophthora batkoi* Bałazy, J. Invertebr. Pathol. 31: 278. 1978. — *Conidiobolus batkoi* (Bałazy) Remaudière et Keller, Mycotaxon 11: 330. 1980.

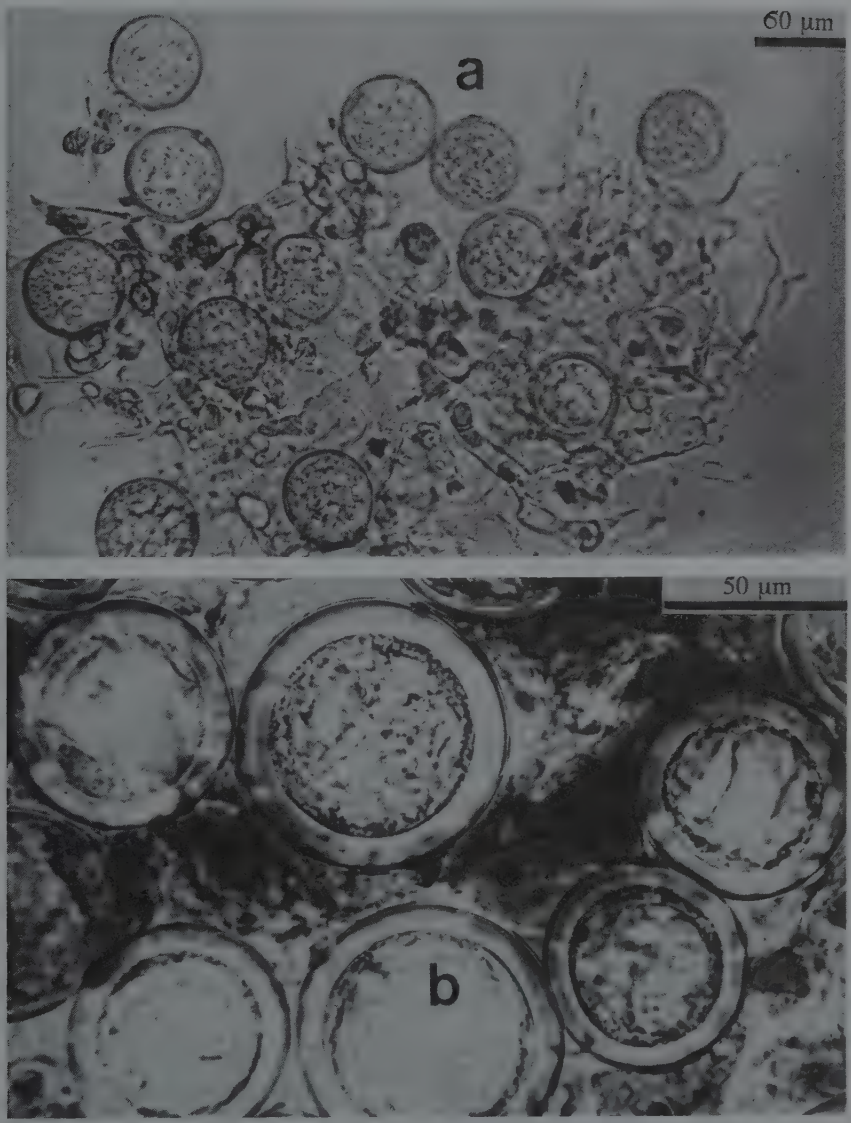


Fig. 21. Azygospores of *Entomophaga diprionis*: a — young, thin-walled, b — mature (from larvae of *Diprion simile*, Forest District Krusza near Nowogród and Gniewkowo near Toruń).

Hyphal bodies ovoid, irregularly ellipsoidal or amoeboid, 35-90 x 28-35 μm in outlines, 20-70-nucleate. Conidiophores idistinctly distended upwards, flask-shaped, 80-100 x 27-35 μm. Primary conidia broadly pyriform and ovoid, (33-) 43-52 (-57) x 30-37 (-41) μm, subpapillate or papillate, about 45-60-nucleate, with one large central globose vacuole. Secondary conidia of the same type, smaller. Resting spores probably azygospores globose, smooth, hyaline, 30-45 μm in diam., surrounded with walls 2.5-3.5 μm thick. Dead hosts found on underside of leaves of forest undergrowth plants in quite natural position or on stems of grasses with contracted legs.

Distribution and hosts. Poland, Switzerland, on harvest spiders *Oligolophus tridens* C. L. Koch, *Leiobunum rotundum* (Latreille) and *L. blackwalli* Meade.

Occurrence in Poland. Wielkopolski National Park, in the undergrowth of deciduous and mixed reserve forests, in some years common.

Genus *Eryniopsis* Humber

Eryniopsis Humber, Mycotaxon, 21: 258-259. 1984.

Mycelium develops in host's body cavity in form of hyphal bodies or hyphae of oligokaryotic segments. Conidiophores growing as long, almost equally narrow, oligokaryotic hyphae perforating host's cuticle and thickening upwards into clavate conidiogenous cells, single, furcate or sparsely monopodially branched. Primary conidia oligokaryotic (with 4-11 nuclei), unitunicate, elongate ovoid, cylindric or fusoid, straight or curved, discharged forcibly by papilla eversion. Secondary conidia resembling primary ones; capilliconidia without specialized adhesive organ (ahaptospores) may appear. Resting spores budding laterally from gametangia of perental hypha. Rhizoids absent or not differentiated from the vegetative hyphae, without specialized holdfasts. Insect parasites of distinct host specificity.

Type species: *Eryniopsis lampyridarum* (Thaxter) Humber.

Hitherto three species have been included into this genus; two have been found in Poland.

Key to species

1. Primary conidia ovoid 30-35 x 14-20 μm; capilliconidia do occur; on *Chauliognathus pennsylvanicus* De Geer (*Coleoptera*: *Cantharidae*) . . . . . *E. lampyridarum*, p. 131

1*. Primary conidia long ovoid, cylindric or fusiform; capilliconidia unknown; on *Diptera-Nematocera* in moist habitats 2

2. Primary conidia long ovoid or straight cylindric with obtuse ends and weakly marked papillae, 22-51 x 11-19 µm; secondary conidia of two types — short ovoid and fusiform ballospores; rhizoids absent; on adults of *Tipulidae* . . . . . *E. caroliniana*, p. 131

2*. Primary conidia slender, narrow fusiform, usually bent; secondary conidia like the primary ones; rhizoids hypha-like; on adults of *Chironomidae*, *Tipulidae* and related *Nematocera*, in moist sites just over water surface . . . . . *E. longispora*, p. 133

(1.) *Eryniopsis lampyridarum* (Thaxter) Humber

Eryniopsis lampyridarum (Thaxter) Humber, Mycotaxon 21: 259. 1984; — *Empusa* subg. *Entomophthora lampyridarum* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 169. 1988; — *Entomophthora lampyridarum* Thaxter ex MacLeod et Müller-Kögler, Mycologia 65: 858. 1973.

Vegative mycelium filling host's body undescribed. Conidiophores supposed by Thaxter (1888: 170) digitately branched but Humber (1984: 260) did not find any evidence to support this opinion. Primary conidia ovoid, oligokaryotic, 30-37 x 14-20 µm (av. 35 x 15 µm), with obtuse papillae. Secondary conidia oblong ellipsoid capillispores of both ends obtuse, approximately 15-40 x 8-13 µm, formed on capillary sphorophores about 40-65 µm long and 1-1.6 µm thick — as calculated on the basis of Thaxter's (1888: pl. 17) and Humber's (1984: 21, fig. 1) drawings. Rhizoids absent, hosts attached to the leaves or grass by contraction of mouthparts.

Distribution and host. North America (USA) on the beetle *Chauliognathus pennsylvanicus* De Geer (*Cantharidae*).

2. *Eryniopsis caroliniana* (Thaxter) Humber

Eryniopsis caroliniana (Thaxter) Humber, Mycotaxon 21: 259. 1984; — *Empusa caroliniana* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 167. 1888; — *Entomophthora caroliniana* Thaxter ex Keller, Sydowia Ann. Mycol., Ser. 2, 21 (1-6): 88-89. 1978; — *Erynia caroliniana* (Thaxter) Remaudière et Hennebert, Mycotaxon 11: 302. 1980.

Hyphal bodies in dead insects round, producing long, continuous or spersely septate, almost equally narrow or slightly nodular hyphae 3.5-7.5 µm thick, with numerous short, perpendicular outgrowths, sometimes furcate or with single branches; numerous sections deprived protoplasm. They are terminated beyond the host body with single or seldom furcate, distinctly thickened conidiogenous cells

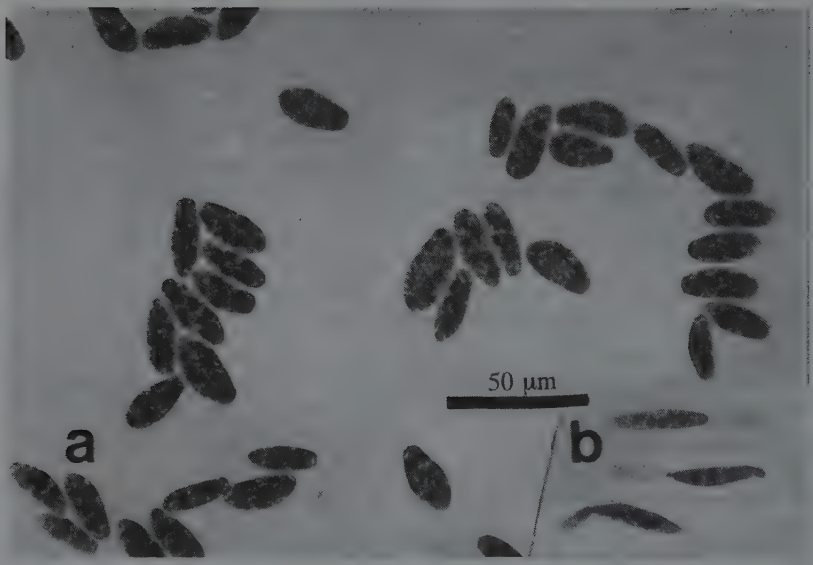


Fig. 22. *Eryniopsis caroliniana* — a — primary and secondary conidia of epapillate type, b — fusiform secondary conidia (from *Tipula paludosa*, Laufen, Bavaria, Germany).

about 60-80 x 6.5-7.5 µm, widened in subapical parts up to 11-15 µm. Primary conidia (Fig. 22a) 4-10 nucleate of two types — oblong ovoid, subpapillate and cylindrical with both ends obtuse of the „epapillata" type after Lakon's (1919) classification, of very variable size: 15-45 x 10-26 µm after Thaxter (1888), 22-51 x 11-19 µm after Keller (1978); in Polish material from the Białowieża National Park the ovoid conidia were (20-) 22-25 (-28) x 11,5-15 µm, the elongate ones were 32-39 x 11,5-18 µm; the papillae in both types were 6-7 µm wide. Secondary conidia of the same type as ovoid primary ones, often little shorter, pyriform or fusiform with acute ends, measuring 30-55 x 7-13 µm (Fig. 22b). Resting spores hyaline, globose 37-55 µm in diam., filled with rather uniform thickly globular content, with walls smooth.

Distribution and hosts. North America, Western and Central Europe in adults of *Tipulidae*.

Occurrence in Poland. Białowieża National Park, moist hardwood forest, on an adult of a big *Tipula* or *Nephrotoma* species.

Remarks. Keller (1978) treated *Entomophthora arrenoctona* Giard, 1888 as conspecific, however, he did not seem to suppport this opinion (Keller 1991).

3. *Eryniopsis longispora* (Bałazy) Humber

Eryniopsis longispora (Bałazy) Humber, Mycotaxon 21: 259; — *Entomophthora longispora* Bałazy, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 29: 221-226. 1981.

Hyphal bodies irregularly ovoid or subglobose, of the measurements 12-35 x 12-27 µm, producing one or two hyphae about 5-10 µm thick, which perforate host's cuticele and give rise of one terminal or two to four monopodially protruding, irregularly flask-shaped conidiogenous cells, 40-90 x 13.5 µm. Primary conidia 4-11 nucleate, fusiform, bent, with conically subacute apical part, 45-75 (-82) x 8-10.5 µm; papillae short of triangular outline. Secondary conidia of the same type and shape, regularly smaller; on specimens of small tipulid and allied gnats collected in the second locality in the Wielkopolski National Park at a road puddle the secondary conidia next by typical ones were also much thicker — even up to 14 µm, rather broadly fusiform — evenly narrowed towards the papillae and ends, with subacute tips. Rhizoids monohyphal without specialized holdfasts.

Distribution and hosts. Poland, Wielkopolski National Park; on small nematocerous gnats of the families *Chironomidae*, *Tipulidae* and *Limoniidae* in moist biotopes, just over water surface.

Genus *Neozygites* Witlaczil

Neozygites Witlaczil, Arch. Mikroskop. Anat. 24: 599-603. 1885; Remaudière et Keller, Mycotaxon 11: 331-332. 1980.

Empusa subg. *Triplosporium* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 152. 1888; — *Triplosporium* (Thaxter) Batko, Bull. Acad. Pol. Sci., Ser. Sci Biol. 12: 324-325. 1964; — *Thaxterosporium* Ben-Ze'ev et Kenneth in Ben-Ze'ev, Kenneth et Uziel, Mycotaxon 28: 323.1987.

Vegative mycelium develops in host's body cavity as globose, subspherical, ovoid or elongate, 4 to about 10-nucleate hyphal bodies, giving rise unbranched, also oligokaryotic conidiophores with the sporogenous cells somewhat swollen, clavate or bottle-shaped. Primary conidia typically tetra- or octokaryotic, in outline globose or ovoid to turbinate with narrow and short but distinctly protruded overpapillar neck closed by truncate or slightly convex oapilla. They are thrown away on a rather small distance — up to 2-3 mm — by papilla eversion. Secondary conidia of the same type, produced on short, tubular sporophores, or capilliconidia of the haptospore type, generally almond-shaped or conical with broadly rounded basal part, furnished with apical gluey haptor. Capillary sporophores 25 to about 100 µm long and about 0.5 µm thick, steadily thinner and thinner toward the end, growing singly or 2-3 from one primary or secondary conidium or from a resting

spore. Primary and secondary conidia as well as capillispores usually smoky-grey, fumose in mass. Resting spores dark, thick-walled, globose, subovoid or ellipsoid, dikaryotic zygospores, originating in result of gametangiogamy and forming extrasporangially between two conjugating hyphal bodies, rarely azygospores of the same appearence. Rhizoids generally absent, lately reported as facultatively occurring in one form (Keller & Wuest 1983). Obligate parasites of arthropods, until now not cultured in vitro.

Type species: *Neozygites fresenii* (Nowakowski) Remaudière et Keller.

Originally only forms of tertakaryotic hyphal bodies and conidia were included into this genus. Kenneth (1977) described under the name „*Entomophthora turbinata*" a form of closely related morphology but containing 7-11 nuclei in hyphal bodies and ballospores and not producing capillispores. Remaudière and Keller (1980) listed this fungus under the generic name *Neozygites*, whereas Ben-Ze'ev et al. (1987) separated it as a representative of the new genus, *Thaxterosporium* Ben-Ze'ev et Kenneth. Keller (1981), who revealed another species of differentiated number of nuclei in the hyphal bodies and showed the abitlity to produce capilliconidia by both these species, came to conclusion that there are no sufficient reasons to separate *Thaxterosporium* from the genus *Neozygites*. Besides the new genus Ben-Ze'ev et al. (1987) — basing on the fine structure of nuclei of *Neozygites* and *Thaxterosporium* representatives — had proposed to separate a new family, *Neozygitaceae*; such an arrangement has been maintained by Humber (1989). Because the number of nuclei is treated as a charcteristic for infrageneric segregation at least in the genera *Entomophaga* and *Entomophthora*, as concerns *Neozygites* Keller's stand point has also been accepted in this review. The resemblance of the morphology, including biometric data, of some species affecting closely related hosts, mainly tetranychid mites, suggests some intraspecific variability. Briefly and incompletely described species *Empusa acaricida* Petch (1942) is supposed to belong to the genus *Neozygites* (Milner 1985).

Eleven species have been included into this genus although some of them were insufficiently charcterized; five species known from Poland.

Key to species

1. Pathogens of sucking phytophagous insects (aphids, thripids and scale insects) 2
1*. Pathogens of mites (*Acarina*) 9

2. Length of the primary conidia does not exceed 18 µm; on thripids and scale insects 3
2*. Length of the primary conidia typically 20-36 µm; pathogens of aphids 6

3. Hyphal bodies spherical or subglobose; pathogens of scale insects . 4
3*. Hyphal bodies oblong, cylindrical or clavate; pathogens of thrips (*Thysanoptera)* 5

4. Primary conidia ovoid, 18 x 9-10 µm; resting spores underclibed; on *Lecanium viride* . . . . . *N. lecanii*, p. 139
4*. Primary conidia 11-16 x 9-13 µm; resting spores globose, 12.5-17.5 µm diam.; on *Phenacoccus* spp. . . . . *N. fumosa*, p. 139

5. Capilliconidia amygdoliform 12-21 x 5.5-10 µm, of L:D ratio about 2; capilliphores thin, 60-120 µm long; resting spores 15-20.5 µm diam. of vermiculate ridged epispore; on *Thrips* spp. . . *N. parvispora*, p. 140
5*. Capilliconidia oblong, cucumber-shaped, (22.5-) 25-30 (-32) x (7.5-) 8-9.5 (-11) µm, of L:D ratio mostly about 3; capilliphores thicker, (16-) 20-30 (-40) µm long; resting spores (19-) 20-23 (-26.5) µm diam.; of unevenly rough epispore; on *Drepanothrips reuteri* . . . . . *N. cucumeriformis*. p. 140

6. Primary conidia of truncate papilla, typically 4 or 5-nucleate, occasionally 3 or 6-nucleate may occur; on aphis of the family *Aphidae* 7
6*. Primary conidia turbinate to pyriform with convex papilla, 7-11-nucleate; on aphids of the family *Lachnidae* . . . . . *N. turbinata*, p. 137

7. Primary conidia of lageniform form to obovoid, 35-38 x 20-30 µm; resting spores unkown . . . . . *N. lageniformis*, p. 136
7*. Primary conidia distinctly smaller, 18-26 x 14-19 µm; zygospores ellispoid 8

8. Primary conidia 18-22 x 14-18 µm, regularly tetrakaryotic, exceptionally 3 or 5-nucleate; capilliconidia 20-27 x 11-14 µm on capilliphores not longer than 60 µm; hyphal bodies tetrakaryotic . . . . *N. fresenii*, p. 136
8* Primary conidia paredominantly 5-nucleate, 24-26 x 18-19 µm; capilliconidia 30-34 x 12-15 µm on capilliphres longer than 100 µm; hyphal bodies 4 and about 8-nucleate . . . . . *N. microlophii*, p. 137

9. Primary conidia 17-22.5 x 13-17.5 µm; capilliconidia unknown; resting spores spherical, 14-18 µm, verrucose, on *Macrocheles peregrinus* Krantz . . . . . *N. acaridis*, p. 142
9*. Primary conidia 12-18 x 10-15 µm; capilliconidia present; resting spores mostly subglobiose or broadly ellipsoid; on *Tetranychidae* 10

10. Capillispores slender, 25-28 x 8-11 µm, of L:D ratio 2.5-3 with conically narrowing apical part and echinulate surface . . . *N. tetranychi*, p. 143
10*. Capillispores squat, usually less than 24 µm long, of L:D ratio ca 2-2.2 smooth; resting spores 14-25 x 14-22 µm . . . . . *N. floridana*, p. 142

1. *Neozygites fresenii* (Nowakowski) Remaudière et Keller

Neozygites fresenii (Nowakowski) Remaudière et Keller, Mycotaxon 11: 332. 1980; — *Empusa fresenii* Nowakowski, Pam. Akad. Umiej. Kraków 8: 171-172. 1883; — *Empusa* subg. *Triplosporium fresenii* Nowakowski ex Thaxter, Mem. Boston Soc. Nat. Hist. 4: 167-169, 1888; — *Entomophthora fresenii* (Nowakowski) Gustafsson, Lantbrukshogsk. Ann. 31: 141-142. 1965; — *Triplosporium fresenii* (Nowakowski) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 325. 1964;

Neozygites aphidis Witlaczil, Arch. Mikr. Ant. 24: 599-603. 1885. — *Empusa freseniana* Nowakowski, Bot. Zeitung (Berlin) 40: 561. 1882. (nom. nud.). — *Entomophthora neri* Gustafsson, Lantbrukshogsk. Ann. 35: 243. 1969.

Protoplasts in early stage of disease round or comma-shaped, intermixed with hyphal bodies typically tetrakaryotic spherical, 14-18 µm in diam., or of the form of short hyphal segments 20-32 x 6-8 µm. Conidiogenous cells slightly widened. Primary conidia subglobose with distinct overpapillar protrusion, 18-20 x 15-18 µm or stronger elongated, somewhat lageniform up to 27 µm long; papillae truncate or weakly convex. Capilliconidia almond-shaped 19-27 x 11-14 µm, with the distal half stronger conically attenuated towards terminal haptor. Capilliphores not longer than 60 µm, except those protruding from the resting spores that may be over 100 µm long. Zygospores broadly ellipsoid or one-sided stronger narrowed, 24-49 x 16-30 µm, thick-walled with black smooth epispore, formed after conjugation of two spherical hyphal bodies.

Distribution and hosts. Overall common, pathogen of many aphid species.

Occurrence in Poland. Great Poland, Lublin, Siedlce, Szczecin, Białowieża, common on aphids, but seldom epizootic; identified hosts: *Aphis fabae* Scop. *Brevicoryne brassicae* (L.) *Microlophium evansi* (Theob.).

(2.) *Neozygites lageniformis* (Thaxter) Remaudière et Keller

Neozygites lageniformis (Thaxter) Remaudière et Keller, Mycotaxon 11: 332. 1980; — *Empusa* subg. *Triplosporium lageniformis* Thaxter, Mem. Boston, Soc. Nat. Hist. 4: 169. 1888; — *Triplosporium lageniformis* (Thaxter) Batko, Bull. Acad Pol. Sci. Ser. Sci. Biol. 12: 403. 1964; — *Entomophthora lageniformis* (Thaxter) MacLeod et Müller-Kögler, Mycologia 65: 858. 1973.

Vegetative mycelium and resting spores not described. Conidiophores simple or reported as pseudodigitate or fasciculate (Thaxter 1888: 169). Primary conidia lageniform with abruptly narrowed over-papillar part, 25.6-34.8 x 16.6-23.9 µm, av. 30.32-1.91 x 19.4-2.06 µm (Aruta & Carrillo 1989: 12). Capilliconidia 29.3-34.8 x 16.5-18.3 µm, ovoid with terminal part elongated conically into moderately short neck appearing „opened" at end. Host attached to substratum by its proposcis.

Distribution and hosts. United States of America and Chile, on aphids *Myzocallis coryli* (Goetze) on *Corylus avellana* and unidentified aphid species on *Betula populifolia* and *Solidago* sp.

3. *Neozygites microlophii* Keller

Neozygites microlophii Keller, Sydowia 43: 82. 1991.

Protoplasts elongate, often one-sided attenuate; hyphal bodies globose, usually 5-nucleate, measuring 21-22 x 20-21 µm when forming conidiophores, or about 10-nuceate (4-14-nucleate) of the diameter 17-17.5 µm when conjugating to form zygospores. Nuclei in the average 3,5 µm (2.5-4.0 µm). Conidiophores short, elongate, terminally swollen. Primary conidia 24-25.5 x 17.5-19 µm, subglobose to pyriform, with distinct over-papillar neck closed by slightly convex or almost truncate papilla, usually 5-nucleate, seldom 4-nucleate. Capilliconidia almond-shaped with considerably less convex ventral line, 30-33.5 x 12-14.5 µm, the thickest in basal half, the end conically elongated and terminated by rounded haptor; capilliphores of first series thin, 155-170 µm long, secondary tertiary and further steadily shorter and shorter. Zygospores dark brown to black, 35.5-43 x 20-23.5 µm, of L:D ratio 1,7-2 germinate by one or more capillary tubes 110-130 µm long.

Distribution and hosts. Switzerland, on the aphids *Microlophium carnosum* Buckton (*Homoptera*: *Aphidae*). One specimen of *Microlophium evansi* (Theob.) filled by the mycelium and resting spores of *Conidiobolus obscurus* intermixed with the resting spores fully corresponding with those of *N. microlophii* (Fig. 23a) was found in the Białowieża National Park.

(4.) *Neozygites turbinata* (Kenneth) Remaudière et Keller

Neozygites turbinata (Kenneth) Remaudière et Keller, Mycotaxon 11: 322.1980; — *Entomophthora turbinata* Kenneth, Mycotaxon 6: 381-390. 1977; — *Thaxterosporium turbinatum* (Kenneth) Kenneth et Ben-Ze'ev in Ben-Ze'ev, Kenneth et Uziel, Mycotaxon 28: 313-326. 1987.

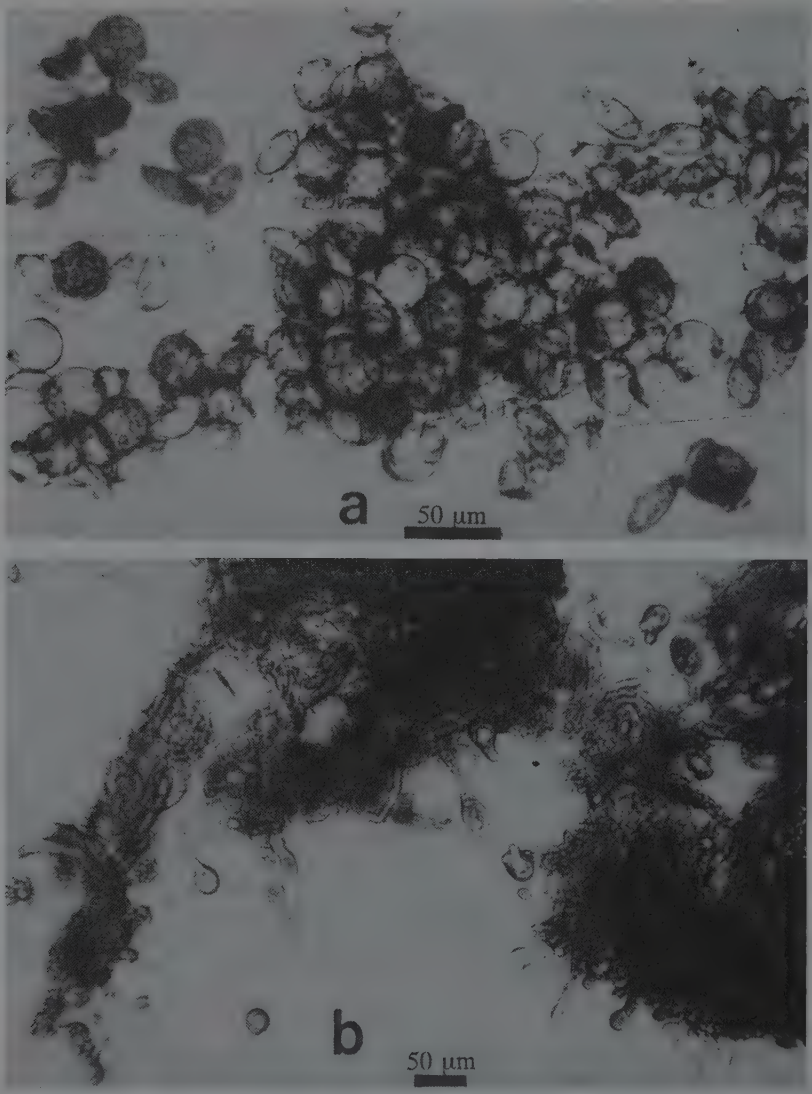


Fig. 23. Cases of mixed infections: a — *Neozygites microlophii* (dark elipsoid resting spores) and *Conidiobolus obscurus*, (round resting spores), (Białowieża National Park), from the aphid *Microlophium evansi*, b — *Entomophaga kansana* (greater pear-shaped conidia and thicker or round hyphal bodies) and *Zoophthora* subg. *Erynia ovispora* (small ellipsoid conidia and thin hyphae, from a calliphoroid fly (Wielkopolski National Park).

Hyphal bodies producing conidiophores 7-9-nucleate of the dimensions 16.6-27.7 x 13.4-20.5 µm, those conjugating somewhat smaller, 12.6-22.1 x 11.9-15.8 µm, (4-) 6-15-nucleate. Conidiogenous cells clavate, 6-10 µm wide. Conidia unitunicate of turbinate shape with broadly rounded apex (17.6)-19.3-22.5 (-25.7) x 11.2-) 12.2-16 µm, 5-10 (usually 7-8)-nucleate, ejected by papilla eversion. Capilliconidia found only as germ conidia, elongate, usually bent (banana-shaped), 22-40 x 7-12 µm, on capillary tubes 35-75 µm long. Zygospores black, ellipsoid or broadly ovoid, 31.6-41 (-44.2) x (15.8-) 17.4-23.7 (-25.3) µm, germinated by capilliphores (see above).

Distribution and hosts. Pathogen of *Pterochloroides persicae* (Cholodk.) in Israel and *Tuberolachnus salignus* Gmelin in Switzerland (*Homoptera*: *Lachnidae*).

(5.) *Neozygites fumosa* (Speare) Remaudière et Keller

Neozygites fumosa (Speare) Remaudière et Keller, Mycotaxon 11: 332. 1980; — *Entomophthora fumusa* Speare, U. S. Dept. Agricult. Bull. 1117: 6. 1922; — *Triplosporium fumosum* (Speare) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 403-404. 1964.

Hyphal bodies spherical tetrakaryotic of the diameter 6-9 µm, or greater, 10-14 µm in diam., containing 4-8 nuclei. Conidiophores unbranched, about 2.5 µm thick with sporogenous cells slightly swollen. Primary conidia broadly ovoid, 11.2-16.2 x 8.7-12.7 µm, av. 14-1.2 x 7.4-1.6 µm, with small truncate papillae. Capilliconidia amygdaliform, 10-15 x 6.2-8.7 µm, with broadly subconical distal half terminated with viscous round haptor; capillary sporophores thin, about 35-70 µm long. Zygospores globose 12.5-17.5 µm in diam., surrounded with about 2 µm thick wall of dark brown, rough epispore.

Distribution and host. Central Africa and South-Eastern parts of North America on *Phenacoccus citri* (Risso) and *Phenacoccus* sp. (*Pseudococcidae*).

(6.) *Neozygites lecanii* (A. Zimmermann) Bałazy, comb. nov.

Empusa lecanii Zimmermann, Meded. Lands Plantent. 44: 25-27. 1901 (basionym); — *Triplosporium lecanii* (Zimmermann) Ben-Ze'ev et Kenneth, Mycotaxon 14: 16. 1970 (nom. conf.); — *Derexiomyces lecanii* Narasimhan et Thirumalachar, Abstr. 2nd Intern. Mycol. Congres Tampa: 466. 1977 (nom. conf.).

Hyphal bodies spherical. Conidiophores simple about 55 µm long and 7-9 µm thick. Primary conidia 18 x 9-10 µm. Capilliconidia 12-20 x 5-10 µm, amygdaliform, somewhat asymmetric, elongated conically towards the apex, borne on capillary sporophores up to 60 µm long and 0.5-0.75 µm thick. Resting spores sub-

globose or broadly ovoid, dark coloured, smooth, germinating by the capillary sporophore.

Distribution and host. South-Eastern Asia, on *Lecanium viride* Green.

Remarks. There are fragmentary, incomplete morphological and biometric data in few references concerning this fungus which is obviously a representative of the genus *Neozygites*. The description has been compiled on the basis of a series of papers (Zimmermann 1901; Petch 1926, 1931; Narasimhan 1970; Narasimhan & Thirumalachar 1977; Ben-Ze'ev & Kenneth 1982).

7. *Neozygites parvispora* (MacLeod, Tyrrell et Carl) Remaudière et Keller

Neozygites parvispora (MacLeod, Tyrrell et Carl) Remaudière et Keller, Mycotaxon 11: 332. 1980; — *Entomophthora parvispora* MacLeod, Tyrrell et Carl, Entomophaga 21: 307-312. 1976.

Vegetative hyphal bodies allantoid, straight-cylindric with obtuse ends; these producing conidiophores greater, 17.5-26.5 x 6.5-10 μm whereas those conjugating — more uniform, oblong ellipsoid, about 25 x 7.5 μm. Primary conidia globose, 11-17.5 x 9-14.5 μm, av. 13.5-11.5-1.0 μm, with the papillate base about 3 x 4.5 μm, distinctly protruding. Capilliconidia narrow ovoid, slightly asymmetric, 12-21 x 5.5-10 μm, av. 14-16 x 7.5-10 μm, with round terminal haptor. Zygospores black, spherical or sometimes flattened, 14.5-20.5 μm in diam., surrounded by thick wall of deeply irregullarly grooved and ridged epispore, giving them strongly rough, somewhat warty appearence.

Distribution and hosts. Europe, on *Thrips* spp. principally *T. tabaci* Lind. (*Thripidae*) in glasshouses and open areas.

Occurrence in Poland. Some samples on *Thrips* sp. collected in glasshouses from materials of the Institute of Plant Protection in Poznań (leg. J. J. Lipa) and from thripids on some weeds in the vicinity of Siedlce (leg. R. Miętkiewski).

8. *Neozygites cucumeriformis* Miętkiewski et Bałazy, n. sp.

Diagnosis. *Corpora hyphalia in hypharum segmenta elongata dimensionibus 30-40 x 7-8 μm et allantoida, recta vel falcata, in dimensiones 28-35 x 9 μm, saepe una ex parte clavata usque ad 12 μm lata. Cellulae conidiogenae breviter lagoenaeformes in dimensiones 20-25 x 9-10 μm, latissime in parte subapicali, saepe leniter curvatae. Conidia primaria globosa, diametro 14-16 μm. cum papillis truncatis vel paulo convexis, 2-2.5 μm longis, 5-7.5 μm latis. Capilliconi-*

dia elongata, cucumeris forma, (22.5-) 25-30 (-32) x (7.5-) 8-9.5 (-11) µm utrimque obtusa, cum glutinego haptore terminali 1.5-2.5 µm longo. Capilliphora (16-) 20-30 (-40) µm longa, at basim 1.5-2 µm crassa. Sporae perdurantes globosae vel subglobosae, diametro (19.5) 20-23 (-26) µm, cum parietibus 1.5-2,5 µm crassis, episporio obscure brunneo, superficie aspera.

Holotypus: *Specimen numero 2397a in collectione* ZBS PAN *designatum, ad Drepanothrips reuteri* (Uzel.) (*Thripidae*) *in* Siedlce (*Polonia Centralis*) *die 9 mensis Julii anno 1992 collectum.*

Hyphal bodies elongate as segments of hyphae, 30-40 x 7-8 µm and allantoid, straight or bent, 28-35 x 9 µm, often with one half claviform widened up to 12 µm. Conidiogenous cells shortly flask-shaped, about 20-25 x 9-10 µm, the widest in subapical part, often slightly curved. Primary conidia globose, 14-16 µm, with papillae abruptly protruding but short — about 2-3 µm and rather wide — 5.5-6.5 µm, of almost truncate basal line. Secondary ballospores similar. Capilliconidia of the shape of cucumber, strongly elongate and almost equally narrow, sometimes with unremarkably thinner distal half, (22.5-) 25-30 (-32) x (7.5-) 8-9.5 (-11) µm, of L:D ratio varying between 2.5-3.5, mostly about 3; their both ends obtuse and the distal haptor umbrella-like, 1.5-2.5 µm long (Fig. 24b). Capilliphores short, (16-) 20-30 (-40) µm, exceptionally longer, at the base 1.5-2 µm thick, conically attenuated to about 1 µm at the end. Resting spores regularly globose or subglobose (19-) 20-23 (26.5) µm in diam., of the wall about 1.5-2.5 µm thick, dark brown with unevenly rough epispore.

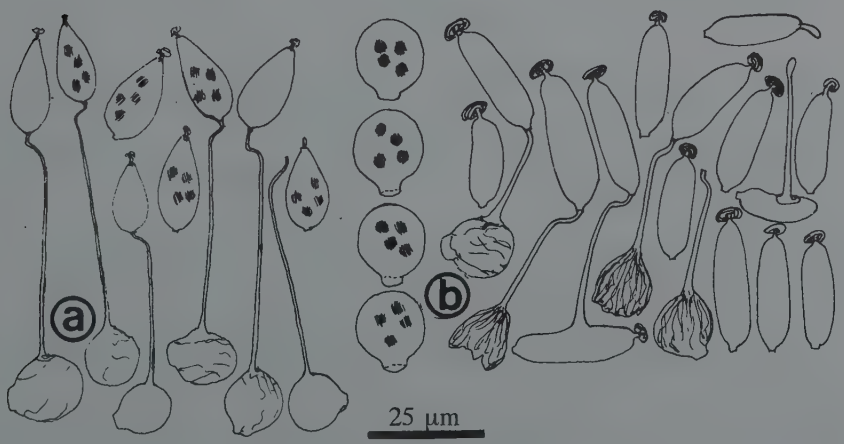


Fig. 24. *Neozygites* spp.: a — capilliconidia of *N. floridana* (from *Tetranychus urticae*, Siedlce), b — primary conidia and capilliconidia of *N. cucumeriformis* (from *Drepanothrips reuteri*, Siedlce).

Distribution and host. Central Poland (Siedlce), on *Drepanothrips reuteri* (Uzel.) (*Thripidae*) on *Vicia* sp.

Remarks. The main characteristics distinguishing this species from *N. parvispora* are shape and L:D ratio of the capillispores, length of capilliphores and greater resting spores.

(9.) *Neozygites acaridis* (Petch) Milner

Neozygites acaridis (Petch) Milner, Trans. Brit. Mycol. Soc. 85: 641-647. 1985; — *Empusa acaridis* Petch, Trans. Brit. Mycol. Soc. 27: 87. 1944.

Mycelium develops inside affected host in form of thin walled ovoid or ellipsoid hyphal-bodies (supposed to be protoplasts by Milner, 1985), measuring about 10-20 x 10-12 µm, becoming spherical 15-20 µm in diam. at the time of host's death and containing 3-5 nuclei. Conidiophores about 60 x 8-10 µm. Primary conidia 17-22.5 x 13-17.5 µm, av. 19.8 x 17.6 µm; secondary conidia of the same type, smaller, some 16 x 13 µm. Zygospores spherical 14.3-17.9 µm, of the brown, thick, finely verrucose epispore.

Distribution and hosts. Australia and Great Britain, in the predatory mites *Pergamasus crassipes* (L.) and *Macrocheles peregrinus* Krantz.

10. *Neozygites floridana* (Weiser et Muma) Remaudière et Keller

Neozygites floridana (Weiser et Muma) Remaudière et Keller, Mycotaxon 11: 331. 1980; — *Entomophthora floridana* Weiser et Muma, Florida Ent. 49: 155-159. 1966; — *Triplosporium floridanum* (Weiser et Muma) Weiser, Folia Parasitol. 2: 121. 1968.

Entomophthora adjarica Tsintsadze et Vartapetov, Bull. Acad. Sci. Georgian SSR, 83: 468.1976; — *Neozygites adjarica* (Tsintsadze et Vartapetov) Remaudière et Keller, Mycotaxon 11: 331. 1980.

Hyphal bodies rod-shaped or slightly clavate, 17-40 x 5-8 µm, typically tetrakaryotic, occasionally containing 3 or 5 nuclei. Conidiophores 5-6.5 µm thick with somewhat widened conidiogenous cell up to 8-9 µm. Primary conidia spherical, 12-17 x 10-14 µm, with short overpapillar neck and truncate papillae. Capilliconidia 14-20 (-24) x 7-10 µm, ovoid, with the distal part conically narrowing towards terminal haptor, surface smooth (Fig. 24a). Resting spores subglobose 14-25 x 14-22 µm, 2-nucleate, smooth, dark brown, with wall 1.5-2.5 µm thick, reported by Tsintsadze and Vartapetov (1976: 466) and Keller (1991: 78) as zygospores.

Distribution and hosts. North America (Florida), Europe, Asia (Israel, Japan), on some tetranychid mites: *Eutetranychus banksi* (McGregor), *Tetranychus urticae* Koch, *Oligonychus hondoensis* (Ehara), *Panonychus citri* Risso and *Eotetranychus sexmaculatus* (Riley). Similar fungi have been reported from tetranychids as *Entomophthora* sp. or *Entomophthora* near *floridana*.

Occurrence in Poland. Vicinity of Siedlce and Konin (Central Poland) on *T. urticae* and *Bryobia* sp., often as an epizootic agent.

Remarks. Polish specimens correspond fully with the original description and illustrations of *Entomophthora adjarica* except that the conjugation of hyphal bodies has not been observed. Synonymy — after Keller (1991).

(11.) *Neozygites tetranychi* (Weiser) Remaudière et Keller

Neozygites tetranychi (Weiser) Remaudière et Keller, Mycotacxon 11: 332. 1980; — *Triplosporium tetranychi* Weiser, Folia Parasitol. (Praha) 15: 115-122. 1968. — *Entomophthora tetranychi* (Weiser) MacLeod et Müller-Kögler, Mycologia 65: 869-871. 1973.

Hyphal bodies typically di- to tetrakaryotic, oblong, 20-30 x 4-6 µm. Conidiophores 30-40 x 4-6 µm, unbranched. Primary conidia globose with short and about 4-5 µm wide broad papillar protrusion, 15-17 x 12-15 µm. Secondary conidia of the same type or capillispores produced on capillary sphorophores 30-50 µm long and measuring 25-28 x 8-11 µm; their basal part is broadly rounded and distal one conically elongated and terminated with round, gluey haptor; their surface is minutely pointed. Resting spores originating as azygospores by budding of hyphal bodies; they are ovoid or pyriform, 20-23 x 16-19 µm, surrounded by two-layered wall 0.7-1.1 µm thick, of black epispore with distinct truncate foramen.

Distribution and hosts. Former Czechoslovakia, on *Tetranychus altheae* v. Hanstein (*Acari*: *Tetranychidae*).

Remarks. The fungus seems to be very close to *N. floridana:* the roughness of the capillispores may be an artefact resulting from preparation technics.

Genus *Strongwellsea* Batko et Weiser

Strongwellsea Batko et Weiser, J. Invertebr. Pathol. 7: 455-463. 1965; Humber, Mycologia 68: 1042-1060. 1976.
Erynia Nowakowski ss. Remaudière et Keller, Mycotaxon 11: 333. 1980. p.p.

Development of mycelium restricted to abdominal hemocel in form of mono-, seldom oligokaryotic, oblong or irregular hyphal segments, sometimes branched,

developing in circular holes inside host's abdomen, occasionally entering thoracical segments and growing throughout the nervous knots. Conidiophores monokaryotic, unbranched, clavate, forming pseudohymenial lining of the spheroidal cavity in host's abdomen. Conidia uninucleate, bitunicatae, forcibly discharged by papilla rounding-off through circular opening in ventral side of abdominal sclerites. Resting spores spherical to ovoid with spinulose epispore, according to Humber (1976) not differing from *Tarichium hylemyiae* Lakon (1935), form a compact mass in host's abdomen. Pathogens in adults of calyptrate flies.

Type species: *Strongwellsea castrans* Batko et Weiser.

Key to species

1. Primary conidia elongate ovoid with the sides in outline conspicuously converging towards the base, 25-33 x 12-19 µm, of L:D ratio seldom attaining 2; in adults of *Anthomyidae* (*Diptera*) . . . . *S. castrans*, p. 144
1*. Primary conidia oblong ellipsoid to cylindrical with rounded ends and the sides almost parallel in outline or slightly widened in proximal part, 30-40 x 12-17 µm, of L:D ratio about 2.4; in *Fannia cunicularis* L. (*Muscidae*) . . . . . *S. magna*, p. 145

(1.) *Strongwellsea castrans* Batko et Weiser

Strongwellsea castrans Batko et Weiser, J. Invertebr. Pathol. 7: 455-463. 1965; Humber, Mycologia 67: 1042-1060. 1976. — *Erynia castrans* (Batko et Weiser) Remaudière et Keller, Mycotaxon 11: 333.

Hyphal bodies subglobose of the diam. 30-40 µm, elongate 30-50 x 15-18 µm, 1-, seldom 2-3-nucleate, form a pseudo-plectenchymatic lining around the hole in host's abdomen. Conidiophores unbranched, slightly widened towards the apex with subpapillar neck weakly but distinctly attenuated. Primary conidia freshly prepared in lactophenol 25-33 x 12-19 µm, of L:D ratio about 1.8, but varying between 1.5-2.3 depeding on other preparatory methods. Secondary conidia undescribed. Resting spores spherical to ovoid, 25-60 µm in diam., of thick walls with spinulose epispore, light orange in mass. Growth in vitro on special media weak, without any form of sporulation (Eilenberg et al. 1992).

Distribution and host. North America, Great Britain, Switzerland and Czecho-Slovakia (former), in anthomyiid flies of the genus *Hylemya*. Occurrence in Poland very problable but the species has not been hitherto reported.

(2.) *Strongwellsea magna* Humber

Strongwellsea magna Humber, Mycologia 67: 1057-1058. 1976.

No differences in vegetative mycelium and conidiophores were stressed by Humber (1976) in relation to *S. castrans*. Primary conidia 30-40 x 12-17 µm when freshly mounted in lactophenol, of L:D ratio varying between 2.2-2.7, whereas in paraffin-embedded sections 22-32 x 8-13 µm. One secondary conidium illustrated by Humber (1976: 1050, fig. 9h) as globose. Resting spores spherical, (28-) 40-55 (-58) µm or ovoid when compressed, surrounded with light orange wall of epispore covered by stout, conical spines.

Distribution and host. USA, California, in *Fannia cunicularis* L. (*Diptera*: *Muscidae*).

Genus *Massospora* Peck emend. Soper

Massospora Peck, Report of the botanist. N. Y. State Mus. Nat. Hist., 31st Ann. Rep.: 44. 1879; Soper, Mycotaxon 1: 13-40. 1974.

Hyphal bodies round, ovoid elongate or of irregular shapes, develop in the abdominal part of host's body. Conidial sporulation in alive insects. Conidiophores elongate, unicellular, little differentiated from the elongate hyphal bodies. Primary conidia cryptobitunicate long ellipsoid, ovoid or fusiform, seldom subglobose, typically bi- or trinucleate, but occassionally 1- or even 5-6 nucleate; their walls may be smooth rough or echinulate, thinner and smooth in weakly marked papillar area; conidia passively detached often together with particular parts of deteriorated host's abdominal segments. Resting spores globose of roughly reticulate epispore. Specialized, obligatorily biotrophic pathogens of adults of gregarious cicads, sporulating in living insects and causing deteriotion of their abdomens.

Type species: *Massospora cicadina* Peck.

The widest taxonomical studies on this particular group of entomophthoralean fungi has been carried out by Soper (1974, 1981) who has also given a synoptic key to species. Any species has so far been found in Europe. A number of fungi reported in the past under the generic name *Massospora* appeared either resting spore forms of other *Entomophthoraceae*, — e.g. *Massospora richteri* Bresadola et Staritz = *Tarichium richteri* (Bres. et Staritz) Bubàk, probably resting spore state of *Zoophthora echinospora* (Thaxter) Batko, *M. tipulae* Porter renamed *Tarichium porteri* (Soper) Bałazy (see p. 263 in this review) — or chlamydospores of some hyphomycetes, e.g. *Massospora staritzii* Bresadola.

Hitherto described species are listed below.

1. *M. carinetae* Soper, Mycotaxon 1: 21. 1974; host: *Carineta* sp.; occurrence — South America: Argentina and Brasil.
2. *M. cicadettae* Soper, Mycotaxon, 13: 51. 1981; host: *Cicadetta murrayiensis* Distant, *C. puer* Walker, and *Cicadetta* sp.; occurrence — Australia.
3. *M. cicadina* Peck, Report of the botanist. N. Y. State Mus. Nat. Hist. Ann. Rep. 31: 44. 1879; Soper, Mycotaxon 1: 16-17. 1974; hosts: *Magicicada septendecim* (L.), *M. cassini* (Fisher), *M. septendecula* Alexander et Moore, *M. tredecim* (Walsh et Riley), *M. tredecassini* Alexander et Moore, *M. tredecula* Alexander et Moore; occurrence: North America, USA. Remarks: Soper (1974: 17) considers reports by Kobayasi (1951) in *Platypleura kaempferi* Fabr. from Japan and by Weiser and Stary (1967) in *Dicercoprocta biconica* Walker from Cuba as questionable.
4. *M. diceroproctae* Soper, Mycotaxon 1: 23-24. 1974; hosts: *Diceroprocta delicata* (Osborn), *D. cinetifera, D. cinetifera* var. *viridicosta* Davis; occurrence: North America: Texas.
5. *M. diminuta* Soper, Mycotaxon 1: 22. 1974; host: *Cicada* sp.; occurrence: South America: Brasil.
6. *M. dorisianae* Soper, Mycotaxon 1: 19. 1974; host: *Dorisiana semilata* (Walker); occurrence: South America: Brasil.
7. *M. fidicinae* Soper, Mycotaxon 1: 25. 1974; host: *Fidicina* sp.; occurrence: Central America: Honduras and Mexico.
8. *M. levispora* Soper, Canad. J. Bot. 41: 875. 1963; hosts: *Okanagana rimosa* (Say), *O. sperata* Van Duzee; occurrence: North America: Canada (Ontario), USA (California).
9. *M. ocypetes* Soper, Mycotaxon 1: 19. 1974; host: *Dorisiana bonaerensis* (Berg); occurrence: South America: Argentina.
10. *M. pahariae* Soper, Mycotaxon 13: 54. 1981; hosts: *Paharia casyapae* (Distant); occurrence — Central Asia: Afghanistan.
11. *M. platypediae* Soper, Mycotaxon 1: 23. 1974; host: *Platypedia puntami;* occurrence: North America: USA (California, Utah, New Mexico).
12. *M. spinosa* Ciferri, Machada et Vital, Atti. Inst. Bot. Reale Univ. Pavia, Lab. Crittog., Ser. 5, 14: 17. 1957; host: *Quesada gigas* (Oliver); occurrence: South America: Brasil, Venezuela.
13. *M. tettigatis* Soper, Mycotaxon 1: 20. 1974; hosts: *Tettigates* spp.; occurrence: South America: Chili.

Genus *Zoophthora* Batko

Zoophthora Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol, 12: 323-324. 1964; — Batko, Acta Mycol. 2: 15-21. 1966; — Remaudière et Hennebert, Mycotaxon 11: 301. 1980 (p.p.); — Remaudière et Keller, Mycotaxon 11: 333. 1980 (p.p.).

Erynia Nowakowski, Dzienn. III Zjazdu Lek. Przyr. Polsk., Sekc. Bot., 67-68. 1881 (nom. nud.); — Humber et Ben-Ze'ev, Mycotaxon 13: 507-509. 1981; — Remaudière et Keller, Mycotaxon 11: 332-333. 1980; — Ben-Ze'ev et Kenneth, Mycotaxon 14: 440, 456-457. 1982; — *Entomophthora* ss. Nowakowski, Pamiętn. Akad. Umiej. Kraków, Wydz. Mat.-Przyr. 8: 176.1883: — Lakon, Z. angew. Ent. 5: 174. 1919. — *Empusa* subg. *Entomophthora* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 152. 1888.

Vegetative mycelium develops inside the host, as hyphal bodies of the form of hyphal segments often branched or filamentous. The following specialized vegetative structures grow from intramatrical mycelium perforating host's cuticle:

— rhizoids, growing singly or in pseudorhizomorphs in the ventral side of hosts; they could be ended with few thin filamentous irregular branches or by rich and dense sinuose branching, forming often disc-like holdfasts with fiord-like margins (Fig. 9);

— pseudocystidia, growing singly before conidial sporulation and scattered all over the dorsal host's surface; thay are usually stiff, conical or equally narrow, often much thicker than common aerial hyphae or conidiophores and clavate, nodular or furcate at tips (Fig. 10, 29c);

— conidiophores, growing usually in bunches or fascicles of equally narrow oligokaryotic hyphae, digitately or at least dichotomously branched at ends, forming dense clusters of monokaryotic sporogenous cells (pseudohymenium) (Fig. 6d, 29b).

Primary conidia bitunicate, monokaryotic, pear-shaped or elongate, forcibly discharged by rounding-off of the papillae. Secondary conidia resembling the primary ones or — especially in further series — more plump, produced on short, tubular sporophores; capillispores and tetraradiate or stellate spores occur in some groups or species. Resting spores spherical or ovoid, hyaline or coloured, thick-walled, with smooth, ornamented, warty or spinulose episporium, originating extracellularly after gametangiogamy or as azygospores. Arthropod parasites mainly oligo- or monophagous.

Type species: *Zoophthora radicans* (Brefeld) Batko.

In few species rhizoids do not appear or unmentioned in descriptions, sometimes facultatively non-occurring (Ben-Ze'ev & Kenneth 1982). In many species pseudocystidia are reported as lacking, however, their presence could become unnoticeable because of slight outstanding among sporogenous cells or collapsing in advanced phases of conidiation.

Batko (1964c) separated the great group of species having monokaryotic bi-

tunicate conidia and branched conidiophores, producing rhizoids and pseudocystidia as the new genus *Zoophthora*. Later (Batko 1966b), considering peculiar differences between particular sub-groups, he divided this genus into four subgenera. However, Remaudière and Hennebert (1980) and Remaudière and Keller (1980) stressed that Nowakowski (1883) placed the name *Erynia* as the facultative synonym of *Entomophthora* sensu Nowakowski, so Batko's genus *Zoophthora* should be replaced by *Erynia* Nowakowski on the principle of priority, although they considered resonable to maintain the generic name *Zoophthora* Batko for the species producing capillispores and fasciculate rhizoids. This inconsistency had been removed by Humber and Ben-Ze'ev (1981) and Ben-Ze'ev and Kenneth (1982). Several years later Humber (1989) came to conclusion that the name *Erynia* Nowakowski, 1881, as nomen nudum, cannot be applied as a valid generic name. Simultaneously he elevated all four Batko's subgenera to the generic rank. Keller (1991) maintained, however, the systematic arrangement proposed by Reaudière and Hennebert (1980) and Remaudière and Keller (1980). In the author's own opinion the set of features criteria of the group defined under the generic name *Zoophthora* Batko, 1964 is so consistent that it should not be divided on this taxonomic level. Thus, applying the generic name *Zoophthora*, the subgenera have been maintained according to Ben-Ze'ev and Kenneth (1982) and Li and Humber (1984) statements.

Key to subgenera

1. Pseucystidia distinctly, two to several times thicker than conidiophores, usually long and often clavate, nodular or furcate at tips; secondary conidia of the common type like primary or small spherical ballospores and sometimes tetraradiate; rhizoids monohyphal without differentiated holdfasts or lacking; mostly in moist habitats . . . . . subg. *Erynia*, p. 149

1*. Pseudocystidia little thicker than conidiophores or not at all, often indistinct; secondary conidia of the common type or capillispores; rhizoids monohyphal and/or fasciculate, ended with disc-like holdfasts or groups of sinuose branches 2

2. Capillispores and pseudorhizomorphs of rhizoids present; primary conidia cylindrical or long ellipsoid, with papillae almost as wide as conidium diameter . . . . . subg. *Zoophthora*, p. 201

2*. Capillispores and rhizoidal pseudorhizomorphs lacking; primary conidia usually pear-shaped or clavate, rarely oblong, subellipsoid 3

3. Rhizoids ribbon-like, little thicker than conidiophores or not at all, termi-

nated with disc-like holdfasts of sinuose margins often with subterminal, asymmetric, reticulate groups of branches in places of their touching to substrate (in *Z. delphacis* rhizoids lacking) . subg. *Neopandora*, p. 171

3*. Rhizoids not thicker than conidiophores or aerial vegetative hyphae, without specialized holdfasts or at least with few lose, short branchlets . . . . . subg. *Furia*, p. 160

Subgenus *Erynia* (Nowakowski) Batko

Zoophthora subg. *Erynia* (Nowakowski) Batko, Acta Mycol. 2: 18. 1966; — *Erynia* Nowakowski, Dzienn. III Zjazdu Lek. Przyr. Polsk., Kraków, 6: 67. 1881 (nom. nud. — as the generic name); — *Erynia* Nowakowski ss. Remaudière et Hennebert, Mycotaxon 11: 301-304. 1980 (p.p. — as the generic name): — *Erynia* subg. *Erynia* Batko ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 459. 1982; — *Erynia* (Nowakowski ex Batko) Remaudière et Hennebert emend. Humber, Mycotaxon 34: 448-449. 1989 (as the generic name).

Hyphal bodies elongate or irregularly round, ovoid or ellipsoid from which thick, tubular, sparingly branched hyphae protrude. Conidiophores poorly or moderately branched in top parts. Primary conidia ovoid, short claviform, pyriform, conical or elongate, obtuse fusiform, sometimes of variable shapes in the same species. Secondary conidia ballospores similar to the primary ones, globose to broadly ovoid with small, strongly protruding papillae or in water habitas of the „tetraradiate" type. Pseudocystidia prominent, very thick, two to several times thicker than conidiophores, cylindric or obtuse conical, often nodulous or furcate at ends (Fig. 10c, d, e). Rhizoids monohyphal usually wider than vegetative hyphae, not modified at ends or with few, short irregular branchlets ascending on substrate. Resting spores formed in result of the *Spirogyra*-like conjugation of two different hyphae, originating from one zygangial outgrowth close to the point of junction, or arise as azygospores by direct budding of parental cells.

Type species: *Zoophthora ovispora* (Nowakowski) Batko.

The species occurring in moist habitats groupped in this subgenus show often some variability range suggesting either infraspecific differentiation or wider range of species very close with regard to the morphology. It is, however, difficult to decide if old, brief descriptions neglecting some morphological details (e.g. „*Entomophthora Henrici*" Molliard) are really separate species. Thorough, modern technics of investigations proposed by Descals and Webster (1984) may provide some new taxonomical features for this group of fungi (tetraradiate, branched conidia and the ability to produce small, round secondary conidia, characteristics of the development in water and others).

Key to species

1. Primary conidia conically narrowing towards apex and often pointed or subacute at tips 2
1*. Primary conidia with broadly rounded or at least obtuse apical parts 3
2. Primary conidia 25-80 x 12-14 µm with rather broad base, slightly widened in the basal third, then steadily narrowing towards subacute or acute tips; on adult *Culicidae* and *Chironomidae* . . . . . *Z. conica*, p. 154
2*. Primary conidia 30-45 x 7-9 µm, the thickest in central portion, then abruptly attenuated into elongate and rather thin distal part; on very small nematocerous flies . . . . . *Z. gracilis*, p. 156
3. Primary conidia with strongly distended distal half, pyriform or broadly claviform, with about 10 µm long obtuse conical papillae; on larvae, pupae and adults of *Culicidae* and *Chironomidae*, mostly floating on water surface . . . . . *Z. aquatica*, p. 152
3*. Primary conidia ovoid, narrow claviform or obtuse fusiform, often bent, with short conical or convex papillae (in outline triangular or arcuate) 4
4. Primary conidia mostly ovoid, radially symmetric, seldom with hardly asymmetrical papillae 5
4*. Primary conidia usually curved, bilaterally symmetric 9
5. Primary conidia turbinate to narrow ovoid with very narrow papillae, not wider than 1/3 of maximal conidium diameter 6
5*. Primary conidia round-ovoid, claviform or obtuse fusiform 7
6. Primary conidia 18-25 x 11-15; pathogen of small nematocerous flies . . . . . *Z. montana*, p. 156
6*. Primary conidia 12.5-20 x 7-13.5 µm: pathogen of aphids . . . . . *Z. erinacea*, p. 155
7. Primary conidia ovoid to somewhat lageniform 14-16 x 6-8 µm, with short, neck-like constriction towards base closed by almost truncate papillae; zygospores ellipsoid, 40-46 x 23-32 µm; on flies of the family *Anthomyidae* . . . . . *Z. delpiniana*, p. 155
7*. Primary conidia with distinctly convex papillae; zygospores — if present — globose 8
8. Primary conidia 22-28 x 12-14 µm regularly ovoid, with papillae arcuate, about as wide as a half of conidium diam.; zygospores about 31 µm in diam.; on adults of different *Diptera* in moist habitats *Z. ovispora*, p. 151
8*. Primary conidia ovoid to clavate, 16-42 x 10-19 µm (mostly av. 33 x 16 µm), seldom slightly bent near base; papilla 5-7 µm wide; on adults of *Nemouridae* (*Plecoptera*) . . . . . *Z. plecopteri*, p. 157

9. Primary conidia strongly variable, pyriform to oblong claviform often curved, (15-)18-30 x 7-11 µm; on small flies . . . *Z. variabilis*, p. 159
9*. Primary conidia of pyriform shape not produced, irregularly oblong or/and fusiform conidia greater and thicker 10
10. Primary conidia obtuse fusiform 25-27-40 (-55) x 10-15 µm, mostly straight or only with slightly bent over-papillar neck; pseudocystidia even 70-90 µm thick, often branched in top parts; on adult tipulids and other flies . . . . . *Z. sepulchralis*, p. 158
10*. Primary conidia mostly claviform or crescent-shaped, usually bent . 11
11. Primary conidia narrow crescent-shaped, claviform or somewhat obtuse fusiform, 30-35 x 8-10 µm, usually the thickest in central part; zygospores 40-60 µm in diam., with brownish epispore and brown appendicular hyphae, formed externally; on *Trichoptera* . . . . *Z. rhizospora*, p. 158
11*. Primary conidia of both ends obtuse, 25-40 x 10-15 µm, the thickest in top parts, curved; zygospores colourless, intramatrical; on flies . . . . . *Z. curvispora*, p. 154

1. *Zoophthora ovispora* (Nowakowski) Batko

Zoophthora ovispora (Nowakowski) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 405. 1964; — *Entomophthora ovispora* Nowakowski, Bot. Ztg. 35: 220. 1877; — Pam, Akad. Umiej., Wydz. Mat.-Przyr. 8: 160-163. 1883; — *Zoophthora* subg. *Erynia ovispora* (Nowakowski) Batko ex Batko, Acta Mycol. 2: 18. 1966; — *Erynia ovispora* (Nowakowski) Nowakowski ex Remaudière et Hennebert, Mycotaxon 11: 301. 1980 (comb. inval.); — *Erynia* subg. *Erynia ovispora* Nowakowski ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 459. 1982 (comb. inval.); — *Erynia ovispora* (Nowakowski) Remaudière et Hennebert ex Humber, Mycotaxon 34: 449. 1969.

Mycelium inside the host's body at first in form of round ovoid or somewhat polymorphic protoplasts, often with lateral nodules or buds, transforming into elongate hyphal bodies with age, from which typical hyphae 6-15 µm thick protrude. Conidiophores 7.5-17 µm thick, with several usually dichotomous branches at different levels in top part. Primary conidia (Fig. 25a) typically ovoid or ellipsoid 23-28.5 x 12-14, radially symmetric, with semispherically convex papillae 6.5-7.5 µm wide. Secondary conidia similar, usually of L:D ratio smaller than 2. Pseudocystidia 100-250 x 15-30 µm, wide obtuse, often distinctly nodulous ends, sometimes furcate; their bases are usually bulbous widened even up to about 60 µm. Rhizoids monohyphal, without specialized holdfasts, usually little thicker than conidiophores. Zygospores globose, about 31 µm in diam., of walls 2.5-3.5 µm thick, with smooth, colourless epispore, protruding extrasporangially from one of conjugating hyphal segments.

Distribution and hosts. Europe, Asia, North America — probably also common in other regions; on adults of different species of flies, mostly of the families *Lonchaeidae*, *Syrphidae*, *Sarcophagidae*, *Calliphoridae*, *Tipulidae*, *Psychodidae* and others, in moist sites at lakes, ponds, streams and in peat bogs.

Occurrence in Poland. Common in investigated areas of Wielkopolski National Park, Holy Cross Mts. National Park, Białowieża National Park, vicinity of Szczecinek, lakes of Notecka Forest, Turew near Leszno, Siedlce, on dipteran adults of aforementioned families. Identified host species: *Lonchaea vaginalis* Fallen and *Melanostoma mellinum* L. (Nowakowski 1883). Appearence under natural conditions in Poland from the first decade of May to the end of September.

Remarks. With respect to host range this species is widely oligophagous. Simultaneously some range of its variability seems to occur because in some localities (e.g. in the protective district Jeziory in the Wielkopolski National Park) on adult *Lauxaniidae* the primary conidia were regularly thicker 25-29 x 15-19 µm and pseudocystidia often abruptly attenuated just over the conidiogenous layer, forming rather thin and acute elongations similar to those of the subg. *Neopandora*. All other structures including resting spores were identical as in typical *Z. ovispora*. Primary comidia from syrphid individuals were of rather ellipsoid shapes (Fig. 25b). Also the species infecting mosquitoes *Culex pipiens* L. (*Culicidae*), described under the name „*Entomophthora Henrici*" by Molliard (1918) seems to be identical or very close to *Z. ovispora* (Waterhouse & Brady 1985).

2. *Zoophthora aquatica* (Anderson et Ringo ex Anderson et Anagnostakis) Bałazy, n. comb.

Entomophthora aquatica Anderson et Ringo, J. Inverteb Pathol. 13: 186. 1969 (nom. inval. — basionym); — Anderson et Anagnostakis, Mycotaxon 10: 350. 1980; — *Erynia aquatica* (Anderson et Ringo) Remaudière et Hennebert, Mycotaxon 11: 301. 1980 (comb. inval.); — *Erynia aquatica* (Anderson et Ringo ex Anderson et Anagnostakis) Humber, Mycotaxon 11: 213. 1981.

Hyphal bodies elongate and branched 130-770 x 8-16 µm; hyphae 8-10 µm in diam. Conidiophores 8-11 µm thick, moderately branched; terminal uninucleate conidiogenous branches claviform or bottle-shaped, about 35 x 15 µm. Nuclei uncommonly big 5-9 µm in diam. Primary conidia elongate pear-shaped, 30-40 x 15-18 µm, with strongly protruded obtuse or conical papillae, up to about 10 µm long and 11-14 µm wide at the base. Pseudocystidia rather short but wide up to about 35 µm, with obtuse or irregularly nodulous tips (Fig. 10c). Hyphae devoid of protoplasm resembling rhizoids, but without modified ends, occur on host's underside.

Distribution and hosts. North America and Central Europe, on culicid larvae, pupae and adults floating on the water surface, in Polish localities adult mosquitoes were also attached to moss, plant stems and emerging branches of fallen trees just over the water surface.

Occurrence in Poland. Sulęczyno Lake near Gdańsk, Łąkie Lake in Notecka Forest near Gorzów Wlkp.; small ponds in the forest reserve of the Wielkopolski National Park near Poznań, on adult mostquitoes, found in May and June.

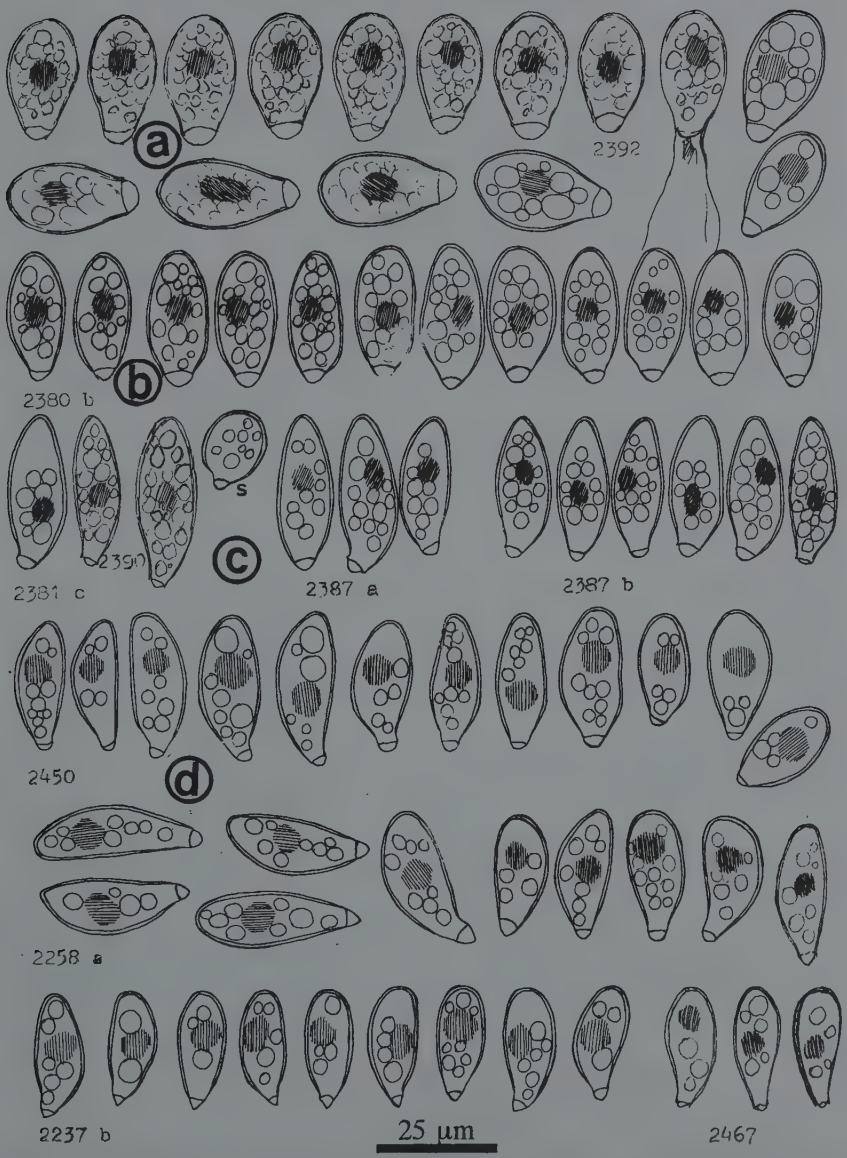


Fig. 25. Primary conidia of some *Zoopthora* subg. *Erynia*: a — *Z. ovispora* from lauxaniid flies, b — *Z.* cf. *ovispora*, from a syrphid adult, c — *Z. sepulchralis* from *Rhagionidae, Calliphoridae* and *Tipulidae*, (S — secondary conidium), d — *Z. variabilis* from *Psychodidae* (Wielkopolski National Park).

3. *Zoophthora conica* (Nowakowski) Batko

Zoophthora conica (Nowakowski) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 404-405. 1964; — *Entomophthora conica* Nowakowski, Pam. Akad. Umiej. Kraków, Wydz. Mat.-Przyr. 8: 155. 1883; — *Empusa* subg. *Entomophthora conica* Nowakowski ex Thaxter, Mem. Boston Soc. Nat. Hist. 4: 186-187. 1888; — *Zoophthora* subg. *Erynia conica* (Nowakowski) Batko ex Batko, Acta Mycol. 2: 18. 1966; — *Erynia conica* (Nowakowski) Remaudière et Hennebert, Mycotaxon 11: 302. 1980; — Humber, Mycotaxon 34: 449. 1989; — *Erynia* subg. *Erynia conica* (Nowakowski) Remaudière et Hennebert ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 459. 1982.

Hyphal bodies ovoid or polymorphic of the size 40-79 µm in outlined contours (Fig. 1c), giving rise the sparingly branched hyphae 8-12 µm thick, often fragmenting into elongate sections. Conidiophores protruding directly from hyphal bodies or hyphae, 10-12 µm thick, with terminal bunches of several branches, sometimes repeatedly bifurcate; conidiogenous branches mostly elongate claviform, about 25-55 x 12-15 µm. Primary conidia fusiform to conical, often bent, 27-80 x 12-14 µm, with round and rather broad base closed with convex papillae about 7 µm wide, and narrowing steadily from approximately 1/3 of their height towards subacute or almost pointed tips. In dry conditions terminal parts of primary conidia loose their content and collapse. Secondary conidia of the same type or small, round, with semiglobose, narrow papillae; in water or very moist condition, tetraradiate secondary conidia may be produced. Pseudocystidia of different length, up to about 400 x 20-35 µm, of slightly converging sides and blunt apex. Rhizoids (Fig. 9a) monohyphal, rather numerous, ribbon-like, often with single thin irregular branches spreading over a substrate from their ends. After conidial sporulation the remainings of host insects covers with white, somewhat undulate hyphae, 10-15 µm thick, difficult to burst. Zygospores spherical, colourless, 30-50 µm in diam., covered by walls 3-4 µm thick, of smooth epispore.

Distribution and hosts. Europe, North America, Asia, Australia, probably also in other regions, common on *Culicidae* and *Chironomidae* around lakes, ponds and at river or brook banks, just over the water surface.

Occurrence in Poland. Common during all vegetation season beginning from May, in many localities all over the country: vicinity of Drezdenko, Kościerzyna, Leszno, Poznań, Siedlce, Szczecinek, Turew, Warszawa. Despite careful searches not found in the Białowieża Forest.

4. *Zoophthora curvispora* (Nowakowski) Batko

Zoophthora curvispora (Nowakowski) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 404. 1964; *Entomophthora curvispora* Nowakowski, Bot. Ztg. 35: 217-220. 1877; — Pam. Akad. Umiej. Kraków, Wydz. Mat.-Przyr. 8: 163-164. 1883; — *Zoophthora* subg. *Erynia curvispora* (Nowakowski) Batko ex Batko, Acta Mycol. 2: 18. 1966; — *Erynia curvispora* (No-

wakowski) Nowakowski ex Remaudière et Hennebert, Mycotaxon 11: 302. 1980; — *Erynia* subg. *Erynia curvispora* Nowakowski ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 459. 1982; — *Erynia curvispora* (Nowakowski) Remaudière et Hennebert ex Humber, Mycotaxon 34: 449. 1989.

Conidiophores growing from round hyphal bodies, rather short, bifurcate, with a number of digitately arranged claviform or flask-shaped conidiogenous cells at ends. Primary conidia somewhat claviform, 25-40 x 10-15 µm, usually bent, broadly round on distal ends, little narrower at bases, with obtuse papillae. Secondary conidia similar or almost globose with small, sharply protruding papillae. Pseudocystidia rather short, obtuse conical, seldom over 100 µm long, 20-30 µm broad at the level of conidiogenous layer and about 10-12 µm at tips. Rhizoids monohyphal, numerous. Zygospores globose 30-40 µm, smooth, of the walls 2-3.5 µm thick.

Distribution and hosts. Europe, on small *Diptera* in moist habitats (identified families *Simuliidae* and *Chironomidae*).

Occurrence in Poland. Warszawa, Lublin, Krasnystaw, Wielkopolski National Park, on *Simulium latipes* Meigen and some unidentified, small flies and on floating on water surface *Podura* sp. (*Collembola*). By the author found in May.

(5). *Zoophthora delpiniana* (Cavara) Bałazy, n. comb.

Entomophthora delpiniana Cavara, Nuov. Giorn. Bot. Ital. (N. S.) 6:422. 1899 (basionym); — Lakon, Z. angew. Entomol. 5: 180-181. 1919; — *Erynia delpiniana* (Cavara) Humber, Mycotaxon 13: 212. 1981; — Humber, Mycotaxon 34: 449. 1989; — *Erynia* subg. *Erynia delpiniana* (Cavara) Humber ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 459. 1982.

Conidiophores about 6.5 µm thick, ramified in top parts. Primary conidia ovoid 14-16 x 6-8 µm, with basal parts elongated into narrowing neck, closed by almost truncate papillae (after Lakon 1919, p. 180 of truncata-lageniform type). Pseudocystidia long, cylindrical 200-300 x 20-26 µm, with obtuse ends, sometimes furcate. Resting spores ellipsoid kidney-shaped, 40-46 x 23-32 µm, reported as intercalar and terminal azygospores. Neither secondary conidia nor rhizoids are mentioned in original description.

Distribution and hosts. Italy, on calyptrate flies, among them *Polietes lardaria* Fabr. (*Diptera*: *Muscidae*) has been identified; known only from the type locality.

(6). *Zoophthora erinacea* Ben-Ze'ev et Kenneth

Zoophthora erinacea Ben-Ze'ev et Kenneth, Mycotaxon 10: 219-232. 1979; — *Erynia erinacea* (Ben-Ze'ev et Kenneth) Remaudière et Hennebert, Mycotaxon 11:

302.1980; — *Erynia subg. Erynia erinacea* (Ben-Ze'ev et Kenneth) Remaudière et Hennebert ex Ben-Ze'ev Kenneth, Mycotaxon 14: 459. 1982.

Hyphal bodies as elongate irregular, often branched segments, of approximate measurements 40-80 x 7-20 µm, intermixed with longer, sparsely septate hyphae. Conidiophores about 4.7-7.2 µm thick, repeatedly dichotomously or somewhat digitately branched. Primary conidia turbinate to short claviform (12.6-) 15-18 (-20.5) x (7.1-) 8-11 (-13.4) µm (av. 16.5 ±13 x 9.3 ±11 µm). Secondary conidia ovoid, smaller. Papillae both in primary and secondary conidia slightly arcuate. Pseudocystidia about 200 or more µm sticking out over the conidiogenous layer, 15-40 µm thick at this level, unmarkedly narrowing towards obtuse tips, sometimes furcate in top parts. Rhizoids unobserved. Resting spores light yellow, globose, 27.7-37.1 µm in diam., surrounded with walls 4-7 µm thick of echinulate epispore, formed by budding from one of conjugating elongate hyphal bodies. Host attached to substrate by proboscis.

Distribution and hosts. Israel, on some species of aphids of the genera *Aphis* and *Myzus*; known only from the type locality.

(7). *Zoophthora gracilis* (Thaxter) Batko

Zoophthora gracilis (Thaxter) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 405. 1964; — *Empusa* subg. *Entomophthora gracilis* Thaxter, Mem. Boston. Soc. Nat. Hist. 4: 185-186. 1988; — *Erynia gracilis* (Thaxter) Remaudière et Hennebert, Mycotaxon 11: 302. 1980; — Humber, Mycotaxon 34: 449. 1989; — *Erynia* subg. *Erynia gracilis* (Thaxter) Remaudière et Hennebert ex Ben-Ze'ev et Kenneth, Mycotaxon, 14: 459. 1982.

Conidiophores digitately branched. Primary conidia thin, fusiform, 30-45 x 7-9 µm, often curved, the thickest in central part and strongly attenuated into long and thin distal part of acute apex. Secondary conidia similar or subglobose with strongly protruding small papillae. Pseudocystidia few, rather broad of rounded apex. Rhizoids monohyphal. Resting spores unknown.

Distribution and hosts. North America, on small gnats; known only from the type locality.

Remarks. The essential difference between *Z. conica* and *Z. gracilis* is considerable smaller thickness of the primary conidia in the latter. However, variability range of shapes and measurements of the conidia in *Z. conica* is so great, that one can suggest a necessity of particular studies in the problem of a homogeneity of this species.

(8). *Zoophthora montana* (Thaxter) Batko

Zoophthora montana (Thaxter) Batko, Bull. Acad Pol. Sci., Ser. Sci. Biol. 12: 405. 1964; — *Empusa* subg. *Entomophthora montana* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 180.

1888; — *Zoophthora* subg. *Erynia montana* (Thaxter) Batko ex Batko, Acta Mycol. 2: 28. 1966; — *Erynia montana* (Thaxter) Remaudière et Hennebert, Mycotaxon 11: 302. 1980; — *Erynia* subg. *Erynia montana* (Thaxter) Remaudière et Hennebert ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 459. 1982; — *Furia montana* (Thaxter) Humber, Mycotaxon 34: 451. 1989.

Hyphal bodies round, giving rise tubular hyphae. Conidiophores digitately branched, coalescing over the host in a livid white mass. Primary conidia ovoid to turbinate or short-clavate, 18-25 x 11-15 µm, usually uniformly attenuating towards bases, closed by narrow, small papillae about 4-5 µm wide, mostly triangular in outline. Secondary conidia shorter, broadly ovoid. Pseudocystidia 2-3 times broader than conidiophores, with ends tapered or obtuse. Rhizoids with slighly lobate, irregular small holdfasts. Resting spores unknown.

Distribution and hosts. North America; on small nematocerous gnats (*Chironomidae*), in a moist locality in mountains.

Remark. Lakon (1919: 180) has suggested to include the name *Empusa sciarae* Olive (1906) into the synonyms of *Z. montana* whereas Humber (1989: 451) has listed it as a separate species of the genus *Furia* (see p. 169 in the present review).

(9). *Zoophthora plecopteri* (Descals et Webster) Bałazy, n. comb.

Erynia plecopteri Descals et Webster, Trans. Brit. Mycol. Soc. 83: 669. 1984 (basionym).

Hyphae and hyphal bodies about 5 µm thick, containing different numbers of nuclei which are mostly elongated up to 28 µm by 4 µm, of finely granular structure. Aerial conidiophores protruding from hyphae or hyphal bodies are simple or branched with conidiogenous cells clavate, up to 10 µm wide. Primary conidia short clavate, straight or somewhat curved, 16-42 x 10-19 µm, mostly 33 x 16 µm attenuating towards the base which is closed by convex papilla 5-7 µm wide; their content dense with numerous oil guttules, nucleus round, about 6 µm diam. Secondary conidia similar, gradually shorter but never spherical. Pseudocystidia long, 36 µm wide at the base, tapering apically and sometimes forked. Rhizoids numerous. Resting spores spherical to „sub-ellipsoid", 34-42 µm in diam., often associated with empty round or lobate cells suspected to be gametangia. Aquatic conidiophores (see Descals et al. 1981) about 5 µm wide, single or branched. Aquatic primary conidia branched, 22-58 x 22-52 µm (mostly 37x28 µm) with central body 4-6 µm broad, typically 3(-4)coronate. Secondary conidia smaller, stellate. Nuclei of aquatic conidia greater, about 10 µm in diam., globose to slightly ellipsoid. They germinate with appressoria in water but form aerial secondary conidia if exposed to air. The culture obtained on special agar medium prepared on

the basis of blended maggots of blue-bottle flies grew very slowly and died without sporulation.

Distribution and hosts. Europe (Great Britain) and New Zealand, on *Nemouridae* (*Plecoptera*) in water and moist habitats.

(10). *Zoophthora rhizospora* (Thaxter) Batko

Zoophthora rhizospora (Thaxter) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 405. 1964; — *Empusa* subg. *Entomophthora rhizospora* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 183. 1888; — *Zoophthora* subg. *Erynia rhizospora* (Thaxter) Batko, Acta Mycol. 2: 18. 1966; — *Entomophthora rhizospora* Thaxter ex Lakon, Z. angew. Ent. 5: 177-178. 1919; — *Erynia rhizospora* (Thaxter) Remaudière et Hennebert, Mycotaxon 11: 302. 1980; — *Erynia* subg. *Erynia rhizospora* (Thaxter) Remaudière et Hennebert ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 459. 1982.

Conidiophores protruding from round hyphal bodies, bi- or trifurcate at 2-3 different levels in top parts. Primary conidia oblong clavate, almost straight or slightly bent to crescent-shaped curved and the thickest in central parts, 30-35 (-42) x 8-10 µm, with obtuse convex, rather small papillae 4-4.5 µm wide. Secondary conidia of all types characteristic for the subgenus. Pseudocystidia coarse, long, of obtuse ends. Rhizoids numerous, monohyphal. Resting spores spherical, 50-60 µm in diam., of brownish, smooth epispore 5-6 µm thick, covered with irregular, appendices of brown hyphal outgrowths; they originate only in extramatrical mycelium as result of typical zygangiogamy.

Distribution and hosts. North America (USA) and Europe (Sweden), on adult caddis-flies (*Phrygaena* spp.) and small diptera in moist habitats.

Remarks. Gustafsson (1965) reports considerably wider measurement ranges both for primary conidia and for zygospores.

11. *Zoophthora sepulchralis* (Thaxter) Batko

Zoophthora sepulchralis (Thaxter) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 405. 1964; — *Empusa* subg. *Entomophthora sepulchralis* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 181-182. 1888; — *Entomophthora sepulchralis* Thaxter ex Lakon, Z. ang. Ent. 5: 178. 1919.; — *Zoophthora* subg. *Erynia sepulchralis* (Thaxter) Batko ex Batko, Acta, Mycol. 2: 18. 1966 — *Erynia sepulchralis* (Thaxter) Remaudière et Hennebert, Mycotaxon 11: 302. 1980; — *Erynia* subg. *Erynia sepulchralis* (Thaxter) Remaudière et Hennebert ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 459. 1982.

Hyphal bodies globose, ovoid or less regular, up to 60 µm in diam. Conidiophores pretty richly branched at ends. Primary conidia long ovoid to ellipsoid or

obtuse fusiform, after Thaxter (1988) 35-48 (-55) x 10-15 µm, in Polish specimens 27-35 x 11.5-13 µm, abruptly or steadily narrowing towards bases into short, neck-like overpapillar constrictions, closed by slightly convex papillae, 4.5-5.5 µm wide, often assymmetrically oriented in relation to the conidium longitudinal axis (Fig. 25c). Secondary conidia similar or small, broadly pyriform. Pseudocystidia coarse, 70-90 µm wide, expanded, furcate or branched at ends (Fig. 10e). Rhizoids monohyphal, numerous. Zygospores spherical, hyaline 35-50 µm in diam.

Distribution and hosts. North America (USA — North Carolina), Central Europe, on adult crane flies (*Tupulidae*) and other *Diptera*.

Occurrence in Poland. Wielkopolski National Park, protective distr. Jeziory, at seasonal pools in mixed deciduous forest, June to August 1990, 1991, 1992, on *Tipulidae*, *Rhagionidae*, *Syrphidae*, *Anthomyzidae* and other *Brachycera*.

12. *Zoophthora variabilis* (Thaxter) Batko

Zoophthora variabilis (Thaxter) Batko, Bull. Acad. Pol. Sci., Ser, Sci. Biol. 12: 405. 1964; — *Empusa* subg. *Entomophthora variabilis* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 183. 1888; — *Zoophthora* subg. *Erynia variabilis* (Thaxter) Batko, Acta Mycol.2: 18. 1966; — *Entomophthora variabilis* Thaxter ex Lakon, Z. angew. Ent. 5: 178. 1919; — *Erynia variabilis* (Thaxter) Remaudière et Hennebert, Mycotaxon 11: 302. 1980; — *Erynia* subg. *Erynia variabilis* (Thaxter) Remaudière et Hennebert ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 459. 1982.

Conidiophores digitately branched; terminal conidiogenous cells cylindric to slightly clavate 20-28 x 7-10 µm. Primary conidia of different shapes (Fig. 25d), from pyriform to narrow clavate, often bent, 18-30 x 7-11(-13) µm, attenuating steadily towards very narrow — 2.5-4 µm wide — papillae, triangular in outline. Secondary conidia similar to the primary ones. Pseudocystidia broadly conical, rather strongly tapered, mostly with blunt apex, sometimes furcate. Rhizoids numerous, monohyphal without terminal modifications or slightly thickened and branched. Resting spores in Polish materials did not appear; these described by Petch (1948) and Gustafsson (1965) as spherical, (25-) 30-40 (-44) µm in diam., smooth, pale brown.

Distribution and hosts. North America, Europe, common on flies, mostly small ones, in moist habitats, close to different, even seasonal water reservoirs.

Occurrence in Poland. Lakes, ponds and streams in the Wielkopolski National Park, Turew near Leszno, Białowieża National Park, Notecka Forest, Kościerzyna near Gdańsk, Szczecinek vicinity, pools and well-heads in the Holy Cross Mts. National Park, usually together with *Zoophthora conica* and *Z. ovispora*, particularly frequent on *Psychodidae*.

Remarks. Waterhouse and Brady (1985) treated it as morphologically identical with *Z. curvispora*; both author's observation and Keller's (1991) analysis refute this stand point.

Subgenus *Furia* Batko emend. Li et Humber

Zoophthora subg. *Furia* Batko, Acta Mycol. 2: 20. 1966; *Erynia* subg. *Furia* Batko ex — Li et Humber, Cand. J. Bot. 6: 662. 1984; — *Furia* Humber, Mycotaxon 34: 450-451. 1989 (as a generic name).

Vegetative mycelium develops in hosts as elongate protoplasts or irregularly shaped, oblong and sometimes branching hyphal bodies. Conidiophores sparingly branched in apical part. Primary conidia ovoid to cylindrical, pyriform or fusoid, sometimes of bilateral symmetry by slightly lateral displacement of papillae in relation to the axis of spores. Secondary conidia of the same type, sometimes of slightly different shape. Pseudocystidia as thick as the conidiophores or with somewhat bulbous base, conically tapered towards the tips. Rhizoids monohyphal or losely fasciculate of a pseudorhizomorph-like structure, without terminal disc-like holdfasts, at most with few irregular, thin branches or slight expansion.

Type species: *Zoophthora virescens* (Thaxter) Batko.

The characteristics of this subgenus — considering emendation by Li and Humber (1984) and Humber's (1989) generic diagnosis — show some intermediate features between the subgenera *Erynia* and *Neopandora* (thin pseudocystidia, rhizoids with irregular terminal branches) as well as between *Neopandora* and *Zoophthora* (pseudorizomorph-like aggregations of rhizoids, cylindrical primary conidia). Some species listed under this name by Humber (1969: 450-451) show much wider range of the differentiation of the rhizoids from hypha-like ones without any terminal modifications to typically expanded into distinct, disc-like structures. On this basis the species *Z. ithacensis* and *Z. vomitoriae* have been transferred to the subgenus *Neopandora*. A number of species seems to be included to the genus *Furia* by Humber (1989) despite some vagueness or incompletness of their characteristics, which was earlier stressed by Ben-Ze'ev and Kenneth (1982a: 410-471), who listed them in a group called „*Erynia* sensu lato" beyond any subgeneric affiliation. Thus the key for identification of the species complied on the basis of existing descriptions should be only treated as some help for more detailed studies on the morphology of considered species. The species *Furia montana* (Thaxter) Humber has been treated here as a representative of the subgenus *Erynia* (see p. 156).

Key to species

1. Primary conidia cylindrical or oblong claviform, to obtuse-fusiform, of L:D ratio 2.2-3.2 2
1*. Primary conidia ovoid to pyriform of L:D ratios about 2 or less; papillae at most half so wide as conidium diameter 4

2. Primary conidia oblong ovoid to short clavate, mostly 19-21 x 7.5-10.5 µm; resting spores rough, black, 40-58 µm in diam., slighly compressed; on caterpillars of *Agrotinae* (*Lepidoptera*: *Noctuidae*) *Z. gammae*, p. 167
2*. Primary conidia almost cylindric, obtuse fusiform or claviform of av. length about 30 µm; 3

3. Primary conidia almost cylindrical or somewhat broadly obtuse fusiform (24-) 28-30 (-32) x (9-) 10-11 (-12) µm; papillae distinctly broader than half of conidium diameter; on caterpillars of *Noctuidae*, mostly *Agrotinae* . . . . . *Z. virescens*, p. 169
3*. Primary conidia oblong claviform, 27-33 x 8.5-10 µm with almost cylindrical top part about 2/3 of total conidium length and basal 1/3 distinctly convergent towards papillae about 4.5 µm wide; on an adult of a brachycerous fly (*Diptera*: *Brachycera*) . . . . . *Z. fumimontana*, p. 166

4. Resting spores dark brown, smooth or verrucose; pathogen of ground beetle larvae *Zabrus tenebrioides* . . . . . *Z. zabri*, p. 170
4*. Resting spores hyaline or at most cream or yellowish in mass; pathogens of other insects 5

5. Pathogens of *Lepidoptera* 6
5*. Pathogens of other insects 9

6. On adult pyralid moths; primary conidia pyriform to ovoid 16-28 x 12-17 µm with broadly obtuse or narrow conical papillae . . . . . *Z. neopyralidarum*, p. 168
6*. On caterpillars 7

7. Primary conidia pyriform, relatively large, av. dimensions 32 x 25 µm; resting spores small, globose, 10-28 µm in diam.; on *Creatonotus gangis* (L.) caterpillars (*Arctiidae*) . . . . . *Z. creatonoti*, p. 164
7*. Primary conidia mostly ovoid, smaller, av. 20-27 x 9.5-16 µm, only exceptionally single exceeding 30 µm in length 8

8. Primary conidia oblong ovoid 16.5-25.5 x 6.5-12 µm, zygospores 21-42 µm in diam; on caterpillars of *Malacosoma* spp. (*Lasiocampidae*) . . . . . *Z. gastropachae*, p. 164
8*. Primary conidia greater, 20.7-32.4 x 11.6-23.7 µm, of broadly rounded distal part; on *Pieris rapae* caterpillars . . . . . *Z. pieris*, p. 171

9. Pathogens of *Diptera* 10
9*. Pathogens of other insects 11
10. Primary conidia ellipsoid or oblong ovoid, 28-30 x 14 µm (single may be greater), converging downwards uniformly to overpapillar neck; on big calyptrate flies (*Musca*, *Lucilla*, *Calliphora* and others) . . . . . *Z. americana*, p. 162
10*. Primary conidia ovoid to turbinate, 18-25 x 12-16 µm, narrowing almost conically towards small papillae; on sciarid flies . . . *Z. sciarae*, p. 169
11. Primary conidia small, (12-) 14-15 (-17) x (7-) 8-9 (-10) µm, short ovoid to pyriform; on *Lygus* sp. (*Heteroptera*: *Miridae*) *Z. minutospora*, p. 168
11*. Primary conidia much greater, mostly 22-28 x 13-16.5 µm, on *Forficula auricularia* (*Dermaptera*: *Forficulidae*) . . . . . *Z. ellisiana*, p. 165

(13). *Zoophthora americana* (Thaxter) Batko emend. Bałazy ex Humber, n. comb.

Empusa subg. *Entomophthora americana* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 179-180. 1888 (basionym); — *Zoophthora americana* (Thaxter) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 406. 1964; *Zoophthora* subg. *Zoophthora americana* (Thaxter) Batko ex Batko, Acta Mycol. 2: 10-11. 1966; — *Erynia americana* (Thaxter) Remaudière et Keller, Mycotaxon 11: 301. 1980; — *Furia americana* (Thaxter) Humber, Myctotaxon 34: 450. 1989.

Hyphal bodies as elongate hyphal segments 3-8 nucleate, 25-130 x 8-10 µm, sometimes with one outgrowth (Fig. 26a), or greater, irregularly round cells from which hyphae and conidiophores protrude. Conidiophores 6-8.5 µm thick, parallelepipedous, moderately branched in top part; terminal conidiogenous branches 30-35 x 9-12 µm. Primary conidia oblong ovoid 28-30 x 14 µm, maximum 35 x 15 µm, with rather strongly inflated distal half of broadly rounded apex and much stronger tapering towards the base forming often overpapillar neck closed by arcuate or semispherically convex papillae about 5-6 µm wide (Fig. 26b). Secondary conidia like the primary. Resting spores colourless, spherical, 38-45 (-50) µm in diam., surrounded by two-layered wall 4.5-5 µm thick of smooth epispore. Pseudocystidia unobserved. Rhizoids numerous, filamentous, often forming losely fasciculate mat around host's abdomen.

Distribution and hosts. North America (USA) and Europe (Great Britain) on *Musca domestica* L., *Calliphore vomitoria* L., *Lucilla caesar* L. and other unidentified flies attached to the undersiedes of leaves and twigs several feet over the ground.

Fig. 26. *Zoophthora* subg. *Furia americana:* a — hyphal bodies, b — primary conidia, c — secondary conidia (from a calliphorid fly, Smoky Mts. National Park, USA).

(14). *Zoophthora creatonoti* (Yen in Humber) Batko emend. Bałazy ex Humber n. comb.

Erynia creatonoti Yen in Humber, Mycotaxon 13: 474. 1981; — *Entomophthora creatonotus* Yen, J. Ins. Pathol. 4: 88-94. 1962 (nom. inval., basionym); — *Zoophthora creatonotus* (Yen) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 406. 1964; — *Zoophthora* subg. *Zoophthora creatonotus* (Yen) Batko ex Batko, Acta Mycol. 2: 10. 1966; — *Erynia creatonoti* (Yen) Remaudière et Hennebert, Mycotaxon 11: 302. 1980. — *Furia creatonoti* (Yen in Humber) Humber, Mycotaxon 34: 450. 1989.

Hyphal bodies elongate as short hyphal segments or irregularly ovoid, 20-84 x 8-28 µm. Conidiophores typically digitately branched, grow in groups or fascicles on all surface of host's body. Primary conidia pyriform, av. 32 x 25 µm, uninucleate; average dimensions of the nuclei 12 x 9 µm. Pseudocystidia few, not characteristic. Rhizoids hypha-like in loose fascicles, without specialized holdfasts. Resting spores mostly azygospores, globose, 10-28 µm in diam., filled with granulose or vacuolate cytoplasm and surrounded with walls of smooth epispore.

Distribution and host. Eastern Asia (Taiwan), on the caterpillars of *Creatonotus gangis* (L.) (*Lepidoptera*: *Arctiidae*). Known only from the type locality.

(15). *Zoophthora gastropachae* (Raciborski) Bałazy, n. comb.

Empusa (*Entomophthora*) *Gastropachae* Raciborski, Kosmos 35 (7-9): 775. 1910 (basionym).

Entomophthora crustosa MacLeod et Tyrrell, Canad. Entomol. 111: 1138-1143. 1979; — *Erynia crustosa* (MacLeod et Tyrrell) Humber et Ben-Ze'ev, Mycotaxon 13: 509. 1981; — *Furia crustosa* (MacLeod et Tyrrell) Humber, Mycotaxon 34: 451. 1989.

Hyphal bodies pyriform, ovoid or clavate, about 25-30x15 µm, giving rise to a single or less frequently two or more thinner, almost parallelepipedous hyphae of the average diameter ca. 10 µm. These hyphae often exceed 350 µm of length and may be bifurcate or profusely branched, forming few cross-walls with age. Conidiophores digitately branched; their branches flask-shaped or club-shaped, sometimes asymmetrical, of the average measurements 20-35 x 11 µm. Primary conidia oblong ovoid, after Raciborski (1910) 20-25 x 8-10 µm, after MacLeod and Tyrrell (1979) 16,5-25.3 x 6.6-12 µm (av. 20.7-1.8 x 9.6-0 .9 µm), narrowing stronger in the basal half towards semispherically convex papillae about 5 µm wide. Pseudocystidia and differentiated rhizoids unobserved, however some possibly adhesive effect of the mycelium growing on the ventral surface of the host has been stressed by MacLeod and Tyrrell (1979) and in Raciborski's material a denser mat of elongated sterile hyphae has been observed in the

region of abdominal legs of the *Malacosoma neustria* caterpillar preserved in KRAM Herbarium. Resting spores spherical of rather variable size, 21-42 µm in diam. (av. 28.9-3.8 µm), surrounded by walls about 3 µm thick of densely sinuose or irregularly rough epispore, singly hyaline but cream to buff in mass. They develop from one of two conjugating hyphal segments as zygospores.

According to MacLeod and Tyrrell (1979) the fungus grows readily on coagulated egg yolk (Müller-Kögler 1959) forming cerebriform colonies and producing both the conidia, which are somewhat greater than those from insects, 18.5-34 x 10-18.5 µm, av. 24.7-3 x 12.6-1.2 µm, and the typical resting spores.

Distribution and hosts. Central Europe (Western Ukraine near Lwów) and North America, on caterpillars of *Malacosoma neustria* (L.), *M. disstria* Hübner and *M. americanum* (Fabr.) (*Lepidoptera*: *Lasiocampidae*).

Remarks. Raciborski's (1910) description of *Empusa* (*Entomophthora*) *Gastropchae* was generally neglected in reviews concerning *Entomophthorales*. The fungus from the caterpillar of *Malacosoma neustria* (L.) deposited in KRAM Herbarium (leg. M. Raciborski) corresponds fully with the description of „*Entomophthora crustosa*" by MacLeod and Tyrell (1979), although the conidiation is rather poor, whereas resting spores are aboundant, not differing from the latter. This fungus was reported under the names *Entomophthora* (*Tarichium*) *megasperma* by MacLeod (1956) and Abrahamson and Harper (1973). Mereover, two unpublished names are connected with materials of the same fungus collected by R. Thaxter and deposited in the Farlow Herbarium, namely *Empusa clisiocampae* written by Thaxter and *Entomophthora malacosomis* given by Kevorkian (MacLeod and Tyrrell 1979). The characteristics of this fungus requires some supplementary data concerning the nature and morphology of rhizoids and description of secondary conidia. Resting spore stage of this fungus is, certainly, unrelated to *Tarichium megaspermum* Cohn (see p. 225)

16. *Zoophthora ellisiana* (Ben-Ze'ev) Bałazy ex Humber, n. comb.

Erynia ellisiana Ben-Ze'ev, Mycotaxon 27: 266. 1986 (basionym); — *Furia ellisiana* (Ben-Ze'ev) Humber, Mycotaxon 34: 451. 1989.

Empusa forficulae var. major Petch, Trans. Brit. Mycol. Soc. 27: 87. 1944 (nom. inval., nec *Entomophthora forficulae* Giard, Bull. Sci. France Belgique 20: 211. 1889).

Hyphal bodies elongate, often somewhat blown at ends, 40-70 x 15-25 µm. Conidiophores 8-11 µm thick, moderately branched at ends, of monokaryotic branches easily separating. Primary conidia ovoid to pear-shaped, (18-) 22-28-) (30) x (12.5-) 13-16.5 (-20) µm (av. 24 x 15 µm), with semiglobose papillae 6.5-7.5 µm wide. Secondary conidia similar, 14-20 x 7-11 µm, with papillae proportionally wide. Pseudocystidia unobserved. Rhizoids monohyphal with a number of irregular branches at end, forming sometimes little widened holdfast. Resting

spores globose, 27-36 (-45) μm in diam., hyaline, surrounded by wall 3-4 μm thick, of shallowly pitted surface.

Distribution and hosts. Europe, Great Britain, Switzerland and Poland, on the earwig *Forficula auricularia* L. (*Dermaptera*: *Forficulidae*).

Occurrence in Poland. Accidentally found on 3 July 1981, in a cabbage head grown in Kościan near Poznań (5 infected specimens of *F. auricularia*).

(17). *Zoophthora fumimontana* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia ut ramosa segmenta hyphalia, usque ad 40-100 μm longa, in crassitudinem inaequalia, ab 8-10 μm usque ad 16 μm, atque etiam 21 μm inflata, crescunt. Conidiophora paulum ramosa, 7-10 μm crassa; cellulae conidiogenae dimensionibus 30-45 x 9-12 μm, in apicis parte conicae. Conidia primaria, dim. 27-33 x (8-) 9-11 (-12) μm, forma peculiari: in supera parte longitudinis circa 2/3 cylindrata, in apice obtusa; in parte proxima circa 1/3 longitudinis convergentia, cum papilla 4.5-5.5 μm lata; intra — solito in 1/3 longitudinis basi — magna vacuola globosa invenitur. Conidia secundaria ovata, dim. 22-25 x 11-13 μm, cum papilla convexa, 5 μm lata. Nuclei in corporibus hyphalibus et conidiis globosis, 7-8 μm. Pseudocystidia subulata, 150-420 μm longa, ad basim 12-15 μm crassa, in apice vehementer usque as 3-4 μm attenuata. Rhizoidea monohyphalia, 7-16 μm crassa, in apice irregulariter incrassata vel cum paucis brevibus ramis. In specimine parvo imaginis dipterorum (Barchycera) parasitans.*

Holotypus. *Specimen numero 2371 b designatum, in silva frondosa* Smoky Mts *prope* Gatlinburg *(America Septentrionalis) die 14 mensis Iulii anno 1981 collectum* (leg. S. Bałazy).

Hyphal bodies at the time of fungus conidial sporulation in form of branched hyphal segments about 40-100 μm long, of uneven thickness, usually 8-10 μm, with numerous puffs up to 16-21 μm. Conidiophores 7-10 μm thick, poorly branched; conidiogenous cells 30-45 x 9-12 μm, in apical part conically attenuated. Primary conidia 27-33 x (8-) 9-11 (-12) μm, of rather peculiar shape (Fig. 27): distal part of about 2/3 of the total length is cylindrical with rounded apex, basal 1/3 convergently attenuating towards 4.5-5.5 μm wide papilla; inside — beneath the center — one great, globose vacuole. Secondary conidia ovoid, 22-25 x 11-13 μm, with convex papillae about 5 μm wide. Pseudocystidia subulate, 150-420 μm long, 12-15 μm thick at the level of conidiogenous layer, then abruptly attenuated at 5-6 μm and elongated into almost equally narrow stretching part terminated by blunt apex 3.5-4.5 μm wide. Rhizoids monohyphal 7-16 μm wide, somewhat widened or with few short irregular branches at ends. Resting spores unknown. In a small spe-

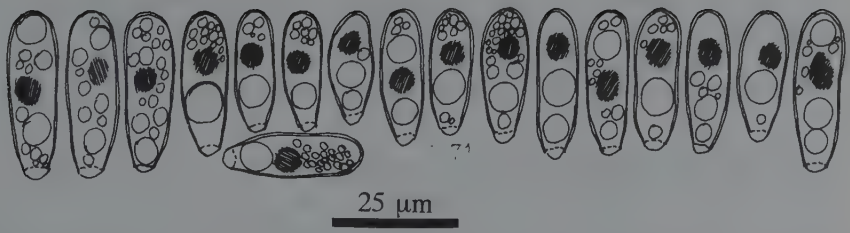


Fig. 27. *Zoophthora* subg. *Furia fumimontana* — primary conidia (from an unidentified small brachycerous fly, Gatlinburg, USA).

cimen of branchycerous fly attached to the underside of a leaf in the hardwood forest floor vegetation in Gatlinburg, Smoky Mts., USA, found on July 14, 1991 .

Remarks. This species distinguishes by the peculiar shape of the primary conidia and pseudocystidia. The conidiophore branching and structure of rhizoids suit exactly to Humber's (1989) diagnosis of *Furia*, so it has been included into this subgenus.

Etymology: Abbreviated Latin translation of the Smoky Mts. „Montes Fumosi".

18. *Zoophthora gammae* (Weiser) Bałazy, n. comb.

Tarichium gammae Weiser, Česka Mycol. 19: 203. 1965 (basionym); — *Entomophthora* (*Tarichium*) *gammae* Weiser ex MacLeod et Müller-Kögler, Mycologia 62: 46. 1970; — *Erynia gammae* (Weiser) Glare et Milner, Austral. J. Bot. 35: 72. 1987.

Hyphal bodies elongate, rounded, unbranched, often bent, about 60-180 x 12-25 µm, 6-42-nucleate; diam. of nuclei 4.5-6 µm. Conidiophores typically branched. Primary conidia oblong ovoid to clavate (16-) 19-21 (-28) x (7-) 7.5-10.5 (-13) µm, slightly asymmetric. Papilla small, slightly convex, 3-4 µm wide. Secondary conidia smaller, oblong ovoid, of proportionally wider papilla. Pseudocystidia almost equally narrow, 8-14 µm thick at the base, 6-8 µm at end. Rhizoids ribbon-like, 6-24 µm wide, any terminal modifications undescribed. Resting spores when young globose to subglobose of rather very stable measurements 45.5-46.5 x 41.5-43.5 µm, when mature 40-58 µm in diam., slightly compressed, black; the wall 3-4 µm thick with peculiar ornamentation of uneven roughness 1-1.5 µm high and 2.5-3 µm broad. According to Keller's (1991: 49, fig. 8) illustration they are zygospores, originating as result of isozygangiogamy.

Distribution and hosts. Central and Western Europe, Australia, on caterpillars *Autographa gamma* (L.) and *Agrotis segetum* (Schiff.) and some allied but unidentified *Agrotinae* (*Lepidoptera*: *Noctuidae*). Reported from the vicinity of Lublin in Poland by Napiórkowska-Kowalik and Machowicz-Stefaniak (1986).

Remarks. According to Weiser's (1965) original decription of *Tarichium gammae* the hyphal bodies produce often chlamydospore-like structures divided by cross walls and host's cadavers are rather flattened than mummified. Humber (1989) listed this species in his genus *Pandora*.

(19). *Zoophthora minutospora* (Keller) Bałazy, n. comb.

Erynia minutospora Keller, Sydowia 43: 60. 1991 (basionym).

Conidiophores branched. Primary conidia short ovoid to pyriform, (12-) 14-15 (-17) x (7-) 8-9 (-10) µm, with almost semiglobose papilla 3-4 µm wide. Secondary conidia similar. Rhizoids 5-18 µm wide, ended with loose radical clusters of root-like branchlets. Pseudocystidia and resting spores unobserved.

Distribution and hosts. Europe (Switzerland and Bohemia), on *Trigonotylus ruficornis* Geoffr. and *Lygus* sp. (*Heteroptera*: *Miridae*).

Remarks. Described characteristics of the rhizoid endings suggests the affiliation of this species to the subgenus *Furia*.

(20). *Zoophthora neopyralidarum* (Ben-Ze'ev) Bałazy ex Humber, n. comb.

Erynia neopyralidarum Ben-Ze'ev, Mycotaxon 16: 276-283. 1982, (basionym, nec *Entomophthora pyralidarum* Petch. Trans. Brit. Mycol. Soc. 21: 36. 1937); — *Furia neopyralidarum* (Ben-Ze'ev) Humber, Mycotaxon 34: 451. 1989.

Vegetative mycelium filling insect's body undescribed. Conidiophores digitately branched. Primary conidia pyriform or ovoid, 16-28 x 12-17 µm, with arcuate convex and rather broad papillae, 6-7.5 µm wide or distinctly smaller ones and short conical, subapiculate. Secondary conidia of the same shapes. Pseudocystidia unobserved. Rhizoids monohyphal, sometimes ramose and slightly irregularly widened at ends.

Distribution and host. Eastern and Southern Asia, on adult pyralid moths, experimentally also on other *Lepidoptera*; identified species – *Spilosoma imparilis* (Butler), *Hyphantria cunea* Drury and *Homona magnanima* Diakonoff.

Remarks. According to Ben-Ze'ev (1982) Petch's (1937) description of „*Entomophthora pyralidarum*" has been based on intermixed materials of „*Conidiobolus apiculatus*" (Thaxter) Remaudière et Keller (at present *C. cercopis* or *Batkoa apiculata*) and the discussed here species.

(21). *Zoophthora sciarae* (Olive) Bałazy ex Humber, n. comb.

Empusa sciarae Olive, Bot. Gaz. 41: 196. 1906; (basionym); — *Erynia sciarae* (Olive) Ben-Ze'ev et Kenneth, Mycotaxon 14: 471-472. 1982; — *Furia sciarae* (Olive) Humber, Mycotaxon 34: 451. 1989.

Mycelium cenocytic, branched at first with sparse cross-walls, abundantly septate with age; some hyphal segments distended or pushing off with single protuberances each give rise to the conidiophores which are digitately branched in terminal parts. Primary conidia ovoid to turbinate, 18-25 x 12-16 µm, distintly stronger narrowing towards the bases closed by prominent but narrow, rounded papillae. Secondary conidia, pseudocystidia and resting spores unmentioned in the description. Rhizoids more or less abundant on the ventral surface.

Distribution and hosts. North America (USA, Wisconsion) and Europe (Denmark), on larvae and adult specimens of *Sciara* sp. (*Diptera*: *Sciaridae*).

Remarks. Lakon (1919) and Gustafsson (1965) considered this species to be identical with Z. subg. *Erynia montana* (Thaxter) Batko due to the similarity of the primary conidia and occurrence on small gnats. Ben-Ze'ev and Kenneth (1982) and Humber (1989) treated them as separate taxa.

22. *Zoophthora virescens* (Thaxter) Batko

Zoophthora virescens (Thaxter) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 406. 1964; — *Empusa* subg. *Entomophthora virescens* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 178. 1888; — *Entomophthora virescens* Thaxter ex Lakon, Z. angew. Entom. 5: 176-177. 1919; — *Zoophthora* subg. *Furia virescens* (Thaxter) Batko ex Batko, Acta Mycol. 2: 20. 1966; *Erynia virescens* (Thaxter) Remaudière et Hennebert, Mycotaxon 11: 302. 1980; Li et Humber, Canad. J. Bot. 62: 659-662. 1984; — *Furia virescens* (Thaxter) Humber, Mycotaxon 34: 451. 1989.

Mycelium filling a mummified caterpillar body comprises strongly interwoven septate and often anastomosing hyphae of uneven thickness 5.5-12 µm with numerous puffs 13-18 µm in diam.; some of them easily fragments into particular elongate hyphal segments. Conidiophores 5-9 µm thick, digitately branched in terminal parts; conidiogenous cells 30-37.5 x 7.8-12.5 µm. Primary conidia elongate, cylindric or claviform, (23.8-) 28-28.5 (-31.6) x (8.7-) 10-11 (-12.5) µm (av. 28.3-1.4 x 10-0.56 µm), of the mean L:D ratio 2.8, with arcuate, rather slightly convex papillae 6.5-7.5 µm wide. Secondary conidia regularly shorter, (21-) 23-26.5 (-28) x (9.5-) 10.5-12.5 µm, of L:D ratio about 2.1, usually stronger inflated in basal half just over convex papillae 4.5-6 µm wide. The content of hyphae, conidiophores and conidia distinctly vacuolized. Pseudocystidia unobserved. Rhizoids hypha-

like without terminal modifications, numerous in the host underside. Resting spores did not appear in the Polish material.

Distribution and hosts. North America, Europe, on caterpillars of a number of noctuid species, mostly from the subfamily *Agrotinae*.

Occurrence in Poland. Wielkopolski National Park, Puszczykowo, on a caterpillar of *Amphipyra pyramidea* L. and an unidentified noctuid species, in June.

Remarks. The above description, prepared on the basis of the Polish material from *A. pyramidea*, corresponds well with hitherto published descriptions of discussed species (Thaxter 1888, Bucher & MacLeod 1974, Li & Humber 1984) supplementing them with some characteristics of vegetative mycelium and secondary conidia. Bucher and MacLeod (1974) have expressed a supposition about a possible connection of the resting spore stage known under the name *Tarichium megaspermum* Cohn with the conidial form of *Zoophthora virescens* (reported under the name „*Entomophthora virescens*"); (see also „Remarks" at *T. megaspermum* in this review, p. 256). Li and Humber (1984) reported pseudocystidia as „spearlike, slightly thicker at base than conidiophores, tapering to narrow tip". Although these structures have not been observed either by Thaxter (1888) or Bucher and MacLeod (1974) the contemporary interpretation of „radially protruding conidiophores from globose hyphal bodies" (Brobyn & Wilding 1977) indicates their presence also in the type material.

(23). *Zoophthora zabri* (Rozsypal ex Ben-Ze'ev et Kenneth) Bałazy ex Humber, n. comb.

Entomophthora zabri Rozsypal, Sborník Českosl. Akad. Zemled. Ved. 24: 85-94. 1951; (nom. inval.); — *Erynia* subg. *Neopandora zabri* Rozsypal ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 465. 1982; — *Furia zabri* (Rozsypal ex Ben-Ze'ev et Kenneth) Humber, Mycotaxon 34: 451. 1989.

Hyphal bodies subglobose or of irregulary lobulate shapes, hyphae branched, about 11 µm thick. Conidiophores bifurcately branched. Primary conidia ovoid of the average measurements 25x 14 µm, max. 29 x 18 µm, of L:D ratio ca. 1.8, polarly bivacuolate, with distinctly prominent subglobose papillae. Secondary conidia undescribed. Pseudocystidia up to about 300 µm long, conically tapered, not thicker than conidiophores, except bulbous bases which measure 50-60 µm in diam. Rhizoids monohyphal without distinctly specialized holsfasts. Resting spores dark brown, smooth or verrucose, globose, 33-40 µm, produced both inside and superficially in hosts.

Distribution and host. Central Europe (former Czechoslovakia), on larvae of *Zabrus tenebrioides* Goeze (*Coleoptera*: *Carabidae*).

Remarks. *Tarichium jaczewskii* Zaprometov (see p. 262) found in Central Asia in the larvae of *Zabrus gibbosus* (Goeze) is probably conspecific. Batko (1964: 405) treated the name *Entomophthora zabri* Rozsypal, 1951 as synonymous with the combination *Zoophthora*

jaczewskii (Zaprometov in Jaczewskii) Batko. Subsequently Humber and Ben-Ze'ev (1981: 509) have transferred it to the genus *Erynia* ss. Humber et Ben-Ze'ev, 1981, correcting simultaneously the Russian author's quotation. However, they have not been unanimous about the position of the name *Entomophthora zabri* which — in opinion of Ben-Ze'ev and Kenneth (1982: 463-465) — should not be nomenclaturally joined with any species name based only on the resting spore stage. The acceptance of Ben-Ze'ev and Kenneth's (1982) basionym *Erynia zabri* by Humber (1989: 451) indicates he inclined to this standpoint.

(24.) *Zoophthora pieris* (Li et Humber) Bałazy ex Humber, n. comb.

Erynia pieris Li et Humber, Canad. J. Bot. 62: 653-663. 1984, (basionym); — *Furia pieris* (Li et Humber) Humber, Mycotaxon 34: 451. 1989.

Hyphal bodies ovoid to elongate of irregular shapes about 30-100 x 6.5-19 µm, sometimes branched, growing after host's death up to more than 400 µm in length. Conidiophores digitately branched, seldom bifurcate or simple, 8-14 µm thick, covering host's body by a continuous pale greenish to cream layer. Primary conidia ovoid, 20.7-32.4 x 11.6-23.7 µm (av. 25.4 x 15.9 µm), with broadly rounded top part and little more attenuating in the proximal part towards rather narrow, arcuate convex papillae about 5 µm wide; content distinctly vacuolized. Secondary conidia similar of smaller L:D ratios, rather short ovoid with abruptly protruding minute, semispherical papillae. Pseudocystidia long, conical, 230-660 µm long, about 20 µm thick at bases, tapering gradually to obtuse tips 3.5-6 µm wide. Rhizoids numerous 10-20 µm thick, monohyphal on lepidopterous hosts but forming fascicles or pseudorhizomorphs on other artificially infected insects, occasionally branched but without discoid holdfasts. Resting spores unobserved.

Distribution and hosts. North America (New York State), on *Pieris rapae* (L.) caterpillars (*Lepidoptera*: *Pieridae*); successful artificial infection obtained for caterpillars of 6 other lepidopteran species of 3 different families and for *Empoasca fabae* (Harris) (*Homoptera*: *Cicadellidae*) and *Musca domestica* L. (*Diptera*: *Muscidae*).

Subgenus *Neopandora* Ben-Ze'ev et Kenneth

Zoophthora subg. *Neopandora* Ben-Ze'ev et Kenneth, Mycotaxon 14: 460-462. 1982; — *Zoophthora* subg. *Pandora* Batko, Acta Mycol. 2: 18-19. 1966 (mistypified by the species of the subgenus *Zoophthora*); — *Pandora* Humber, Mycotaxon 34: 451-453. 1989 (as the generic name).

Mycelium filamentous or in form of hyphal segments often irregularly branched. Conidiophores dichotomously or digitately branched; terminal conidioge-

nous cells monokaryotic. Primary conidia ovoid, pyriform, short claviform or obtuse fusiform, usually subpapillate or papillate. Secondary conidia similar, smaller, more and more plump in consecutive series. Pseudocystidia usually conical of about the same thickness as conidiophores or at most about twice thicker at the bases. Rhizoids monohyphal, often ribbon-like, ended with disc-like holdfasts of sinuose margins or with dense network of irregular branchlets forming reticulate holdfasts; in some species or strains rhizoids lacking. Resting spores usually globose, hyaline or coloured, smooth, rough, warty, spinulose or otherwise ornamented, originating as zygo-or azygospores. Specialized pathogens of insects, mites and harvest-spiders.

Type species: *Zoophthora neoaphidis* (Remaudière et Hennebert) Bałazy.

Remarks. See description of the genus *Zoophthora* (p. 148).

Key to species

1. Pathogens of harvest-spiders and mites . . . . *Z. phalangicida*, p. 196
1*. Pathogens of adult insects or their larvae 2

2. Pathogens of adult flies (*Diptera*) 3
2*. Pathogens of other insects 10

3. Resting spores roughly echinulate or bullate, commonly produced . 4
3*. Resting spores — if present — smooth or with rather shallow roughness or ornamentation 5

4. Primary conidia ellipsoid 21-27 x 9-12 (-14) µm; secondary conidia unlike the primary, mostly short ovoid with almost truncate papillae and a great round wacuole in the center, beneath the discoidally flattened lensiform nucleus, often with hardly marked apical point; resting spores roughly spinulose, yellow to clay coloured sometimes with orange tint in mass; on flies of the family *Lauxaniidae* . . . . *Z. echinospora*, p. 185
4*. Primary conidia 23-37.5 x 12-16 µm; secondary conidia like the primary; resting spores with thickly bullate epispore . . . . . *Z. bullata*, p. 179

5. Primary conidia rather variable — oblong ovoid, ellipsoid or obtuse-fusiform; resting spores globose, smooth, hyaline; on different flies, mostly small *Nematocera* . . . . . *Z. dipterigena*, p. 185
5*. Primary conidia mostly in range of ovoid shapes 6

6. Primary conidia 20-24 x 11-13 µm, with the papillar convexity fluently and smoothly coming into a side spore wall in contour; resting spores glo-

bose about 30 µm, with chestnut brown, smooth epispore; on brachycerous flies . . . . . *Z. muscivora,* p. 194

6*. Papillar convexity of primary conidia usually more or less distinctly protruding from the conidium outline 7

7. Primary conidia relatively big, 28-44 x 12-19 µm; resting spores hyaline, smooth 25-52 in diam. 8

7*. Primary conidia smaller, of the dimension range 14-25 x8-14 µm; resting spores smooth or shallowly ridged with „wavy" outline 9

8. Primary conidia 28-44 x 12-19 µm; resting spores hyaline, smooth 25-52 µm in diam; rhizoids monohyphal with disc-like holdfasts, not unified into continuous hyphal mat around host's body; on flies of the family *Calliphoridae* . . . . . *Z. vomitoriae*, p. 201

8*. Maximal size of primary conidia about 35x15 um; resting spores 35-48 (-50) µm in diam.; rhizoids without terminal, holdfasts, coalescent into continuous hyphal mat around host's body; on big calyptrate flies (*Muscidae*, *Calliphoridae*) . . . . . *Z. americana*, p. 162 subg. *Furia*

9. Primary conidia with strongly separable outer wall, ovoid, 18x12 µm; resting spores globose smooth; on small flies . . . *Z. gloeospora*, p. 191

9*. Primary conidia 14-24 x 8,3-12 µm; resting spores 26-41 µm in diam., rusty brown in mass, with irregularly ridged epispore, thickly rough or wavy in outline; on rhagionid and empidid flies . *Z. ithacensis*, p. 191

10. Pathogens of beetles (*Coleoptera*) 11

10*. Pathogens of other insects 15

11. On larvae of *Zabrus tenebrioides* (*Carabidae*); primary conidia av. 25 x 14 µm (max. 29 x 18 µm); resting spores black-brown with smooth or verrucose epispore, 33-40 µm in diam . . . . . *Z. zabri*, p. 170 subg. *Furia*

11*. On adult beetles; dimension range of primary conidia 19-30 x 9-15 µm 12

12. Primary conidia oblong ovoid or ellipsoid, of L:D ratio usually a little greater than 2, abruptly or conically narrowing in the basal part to small, convex papilla about 4 µm wide; pseudocystidia numerous, prominent, up to 300-400 µm long 13

12*. Primary conidia rather broadly ovoid, of L:D ratio usually less than 2, with broader papillae 6-7 µm wide; pseudocystidia not prominent, usually about several dozen to little over 100 µm long 14

13. On some *Cantharidae;* primary conidia (17-) 18.5-23 (-26) x (9-) 9.5-12

(13) µm, usually abruptly narrowed at the base into short overpapillar neck . . . . . *Z. lipai*, p. 192

13*. On *Phyllobius* sp. (*Curculionidae*); primary conidia narrow-ovoid 20-23 x 10-11.5 µm or oblong-ellipsoid 23-31 x 11.5-14.5 µm, in both cases conically narrowing towards small papillae . . . . . *Z. phyllobii*, p. 199

14. Primary conidia (19-) 21-26 x 11-13 (-14.5) µm, with papillae distinguished from their outline as separate basal convexities; resting spores unknown; on staphylinid beetles (*Philonthus* spp.) . . *Z. philonthi*, p. 197

14*. Primary conidia 18-22 (-24.6) x 10-14 (-16) µm, with papillae weakly convex and fluently coming into conidium outlines or subtruncate; resting sporesunknown; on chrysomelid beetles (*Galerucini*) . . . . . *Z. suturalis*, p. 200

14**. Primary conidia 18-22 x 11-15 µm; zygospores globose, 22-39 (av. 29) µm in diam., colourless, echinulate; on adult bettles of *Brahmina sp. and Anomala rufiventris* (*Scarabaeidae*) . . . . . *Z. brahminae*, p. 178

15. Pathogens of *Rhynchota* 16

15*. Pathogens of other insects 22

16. Typical pathogens of aphids, other hosts may only be infected in laboratory experiments 17

16*. Typical hosts — plant hoppers, white flies or heteropterous bugs . . 19

17. Primary conidia variable, ovoid, ellipsoid to subcylindrical (15-) 20-32 (-40) x (9-) 11-14 (-16) µm; rhizoids typically monohyphal, but may be poorly developed or lacking in dense colonies of host individuals on different aphid-species . . . . . *Z. neoaphidis*, p. 175

17*. Primary conidia shorter, usually ovoid, 16-24 x (7-) 10-12 (15) µm, single the longest do not exceed 27 µm; rhizoids regularly present . . . 18

18. Primary conidia short-ovoid (12-) 15-16.6 (-20) x (7-) 8-10.5 (-12) µm, without overpapillar neck and with slightly convex, rather broad papillae; on aphids *Pemphigus bursarius*, *Aphis umbrella* and related species . . . . . *Z. nouryi*, p. 195

18*. Primary conidia (14-) 16-24 (-27) x (7-) 10-12 (-15) µm, ovoid or short-ellipsoid with prominently protruding, semiglobose papillae; on aphids *Acyrtosiphon kondoi* and related species (experimentally) . . . . . *Z. kondoiensis*, p. 195

19. Pathogens of plant hoppers 20

19*. Pathogens of other bugs 21

20. Rhizoids absent; primary conidia 29-35.5 x 13-17.5 µm; on delphacid plant-hoppers and — experimentally — aphids . . *Z. delphacis*, p. 183

20*. Rhizoids present; primary conidia regularly shorter, ovoid to oblong ovo-

id, 17.5-22.5 x 9.5-11 µm, steadily narrowing in the basal third towards papillae 4.8-5.8 µm broad, on jassid plant hoppers . . . . . *Z. poloniaemajoris*, p. 180

21. Primary conidia up to 20 µm long pyriform in outline, with all proximal part steadily narrowing towards 3-3.5 µm wide papillae; on aleurodids . . . . . *Z. aleurodis*, p. 176

21*. Primary conidia ellipsoid with the basal end abruptly narrowed into short neck, closed by slightly convex, 3-4 µm wide papillae; on small *Heteroptera* . . . . . *Z. heteropteris*, p. 188

22. Pathogens of *Hymenoptera* 23

22*. Pathogens of other insects 25

23. Primary conidia mostly narrow ellipsoid or obtuse subfusiform, seldom oblong ovoid; on larvae of *Tenthredinidae* (*Athalia rosae* L.) . . . . . *Z. athaliae*, p. 177

23*. Primary conidia rather short, ovoid to semewhat pear-shaped; on adult *Hymenoptera* 24

24. Pathogens of ant workers; rhizoids few only in thoracical underside; on *Formica* spp. . . . . *Z. myrmecophaga*, p. 188

24*. Pathogens of braconids; rhizoids numerous in thoracical and abdominal underside; on *Dacnusa* sp. . . . . *Z. dacnusae*, p. 183

25. On caterpillars; primary conidia (13-) 15-18 (-20) x 7-9 (— 11) µm, ovoid to pear-shaped, with the basal half narrowed to semispherically convex papillae about 4 µm wide . . . . . *Z. blunckii*, p. 178

25*. On earwigs (*Forficula auricularia*); primary conidia (20-) 22,5-25,5 (-28,5) x 13-16 µm, ellipsoid or broadly ovoid, slightly narrowed into about 7 µm wide short neck just over papilla . . . . *Z. ellisiana*, p. 165 subg. *Furia*

25. *Zoophthora neoaphidis* (Remaudière et Hennebert) Bałazy, n. comb.

Erynia neoaphidis Remaudière et Hennebert, Mycotaxon 11: 307-312 1980, (basionym); — *Erynia* subg. *Neopandora neoaphidis* Remaudière et Hennebert ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 461-462. 1982; — *Pandora neoaphidis* (Remaudière et Hennebert) Humber, Mycotaxon 34: 452. 1989.

Mycelium filling host's body in from of hyphae or hyphal segments, 32-26 µm long and 6-13 µm thick, often with irregular branches. Conidiophores 6-10 µm thick, digitately branched in terminal parts. Primary conidia ovoid or ellipsoid

usually with distincly convex papillae, (12-) 21-32 (-40) x (9-) 11-14 (-16) µm. Secondary conidia similar, smaller and more variable, sometimes broadly ovoid with hardly convex papillae and weakly marked apical points, containing single, large, round vacuole. Pseudocystidia conical, 12-14 µm thick at bases and 7-9 µm thick at blunt apex, protruding from the subspherical cells 30-40 µm in diam. Rhizoids monohyphal, usually numerous in thoracical and abdominal part of host's body, terminated with flat discs of irregularly sinuose margins and generally rounded outline; sometimes in very dense aphid colonies rhizoids on particular individuals underdeveloped or lacking. Resting spores unknown.

Distribution and host. Common species in the world over although less frequent in tropical regions, on many species of aphids; generally considered to be the most important agent of epizootics in aphid populations.

Occurrence in Poland. Reported from all regions of Poland: Białowieża National Park, vicinity of Jarocin, Karkonoski National Park, vicinity of Wrocław, Kasubian Lakeland (Sulęczyno near Kościerzyna), vicinity of Lublin, Notecka Forest, Poznań and surrounding, Siedle and suburban area, Słowiński National Park, Szczecin and surrounding, Trzemeszno near Gniezno, Turew near Leszno, Warszawa and suburban area, Wielkopolski National Park. Identified host species: *Acyrtosiphon pisum* (Harris), *Amphorophora rubi* (Kaltenbach), *Aphis fabae* Scopoli, *A. frangulae* Kaltenbach in Koch, *A. nasturtii* Kaltenbach, *Aulacorthum solani* (Kaltenbach), *Brachycaudus cardui* (L.), *Brevicoryne brassicae* (L.), *Capitophorus similis* v. d. Goot, *Cryptomyzus ribis* (L.), *Drepanosiphum platanoidis* (Schrank), *Impatientium asiaticum* (Nevsky), *Macrosiphum euphorbiae* (Thomas), *M. prenanthidis* Börner, *M. rosae* (L.), *Microlophium evansi* (Theobald), *Metopolophium dirhodum* (Walker), *Myzus persicae* (Sulzer), *Sitobion avenae* (Fabr.), *S. fragariae* (Walker), *Uroleucon cirsii* (L.), *U. tussilaginis* (Walker), *U. hypochaeridis* (Hille Ris Lambers). Found also on many other unidentified aphid species. Specimens preserved in the Wrocław University Herbarium (WRSL) under the name „*Entomophthora aphidis*" represents this species except the sample from *Anoecia corni* which is true *Zoophthora aphidis* (Hoffmann in Fres.) Remaudière et Hennebert, (see p. 211). Period of appearence from the second decade of May till first frost — usually in November.

Remarks. Since Nowakowski (1883) during the long period this species was wrongly identified and reported as „*Entomophthora aphidis*" Hoffmann in Fresenius (1858). Its systematic position has been established by Remaudière and Hennebert (1980) and Ben-Ze'ev and Kenneth (1982). It is the feeling of the author of the present review that *Z. neoaphidis* in the sense here referred is a complex species.

(26.) *Zoophthora aleurodis* Bałazy et Manole, n. sp.

Diagnosis. *Corpora hyphalia elongata, hypharum segmentis similia, dimensionibus 15-40 x 8-12 µm, saepe cum ramis brevibus vel appendicibus. Conidiophora 6-8 µm crassa in apice digitose ramosa. Cellulae conidiogenae cylindratae vel clavatae, circa 25 µm longae, 10-11 µm crassae. Conidia primaria regulariter piriformia, dimensionibus 16.5-19.5 x 8.5-10.5 µm, ad basim coartata.*

Papillae 3-3.6 latae. Conidia secundaria primariis similia, minora. Pseudocystidia non visa. Rhizoidea monohyphalia, 6-12 µm crassa, scutulis cum marginibus inaequalibus ad finem adhaerentibus. Sporae perdurantes ignotae. In imagine Aleurodidae parasitans, ex Aegopodium podagraria.

Holotypus. *Specimen numero 2154 in collectione* ZBS PAN *designatum, die 18 mensis Iulii anno 1988 in silva urbana* Baneasa, *Bucaresti (Romania) collectum, in praeparatione microscopica depositum.*

Hyphal bodies as irregularly shaped hyphal segments, about 15-40 x 8-12 µm, often with branches or outgrowths. Conidiophores 6-8 µm thick, typically branched; terminal conidiogenous branches claviform, about 25 µm long and 10-11 µm thick in the upper part. Primary conidia (Fig. 7r) regularly pyriform 16.5-19.5 x 8.5-10.5 µm, of the greatest diameter just over the half of their height, narrowing with sinuously concave side outlines forming semicircular papillae 3.1-3.6 µm wide. Secondary conidia of the first succession little smaller, of the same shape; further series unobserved. Pseudocystidia unknown. Rhizoids monohyphal ribbon-like, 6-12 µm wide, with disc-like terminal holfasts of deeply sinuose margins. Resting spores lacking.

Distribution and host. Romania, Baneasa Forest by Bucharest, coll. on 18 July, 1988, on aleurodid adults under leaves of *Aegopodium podagraria* L. in deciduous forest floor vegetation.

Remarks. The shape and size of the primary conidia are similar to those of *Zoophthora* (subg. *Neopandora*) *blunckii* (p. 178), however there are no relation in biology or systematics of the hosts of both species. Undertaken in the same locality attempts at collection of further specimens in June 1989, as well as numerous searches in the Wielkopolski National Park and Turew near Leszno failed, despite the presence of the host species.

Etymology: *Aleurodes* — generic name of the host species.

(27.) *Zoophthora athaliae* (Keller) Bałazy, n. comb.

Erynia athaliae Keller, Sydowia 43: 42-46. 1991, (basionym).

Hyphal bodies elongate of uneven thickness, about 70-160 x 12-35 µm, often with thinner outgrowths less than 10 µm thick; nuclei 5-7 µm in diam. Conidiophores typically branched. Primary conidia mostly narrow ellipsoid or obtuse subfusiform in outline to oblong ovoid, (17-) 21-22 (-30) x (7-) 9-11 (-15) µm, of the papilla 5-6 µm wide, arcuate. Secondary conidia similar to the primary ones or short ovoid with apical point, similar to the shape of *Entomophthopa muscae*-type but monokaryotic. Pseudocystidia about 150 µm long, slightly attenuated toward the obtuse end, at the level of pseudohymenium 7-18 µm in the terminal part 6-10 µm wide. Rhizoids monohyphal, abundant on the ventral side of host's body,

12-25 µm wide, terminated with dense clusters of irregular branchlets. Zygospores spherical to subglobose, (24-) 32-35 (-42) µm, hyaline, surrounded by walls 4-7 µm thick, of smooth epispore.

Distribution and hosts. Switzerland, on larvae of *Athalia rosae* L. (*Hymenoptera*: *Tenthredinidae*), known only from the type locality near Zurich.

Remark. Dense cluster of irregular branchlets ending rhizoids qualify this species to the subgenus *Neopandora*.

(28.) *Zoophthora blunckii* (Lakon ex Zimmermann) Bałazy ex Humber, n. comb.

Entomophthora blunckii Lakon ex Zimmermann, Entomophaga 23: 182-184. 1978; — *Entomophthora blunckii* Lakon, Z. angew. Entomol. 21: 89-95. 1935 (nom. inval., basionym); — *Zoophthora blunckii* (Lakon) Batko, Bull. Acad. Pol. Sci., Ser. Sci.Biol. 12: 405.1964 (comb. inval.); — *Zoophthora* subg. *Erynia blunckii* (Lakon) Batko, Acta Mycol. 2: 18. 1966; — *Pandora blunckii* (Lakon ex Zimmermann) Humber, Mycotaxon 34: 452. 1989.

Hyphal bodies elongate 18-116 x 7-12 µm, sometimes ramose, strongly vacuolized. Conidiophores 8-10 µm thick, irregularly branched at ends. Primary conidia mostly pyriform, sometimes ovoid, (13-) 15-18 (-20) x 7-9 (-11) µm, the thickest at about the half of their height and stronger narrowed towards the base forming short overpapillar necks, from which semispherical, 3-4 µm wide, papillae protrude. Secondary conidia similar, smaller. Pseudocystidia 95-230 µm long, not thicker than hyphae and conidiophores, at ends obtuse. Rhizoids monohyphal with disc-like holdfasts, numerous. Resting spores unobserved.

The strains of this fungus grow well on media containing egg yolk forming white, floccose mycelium; the substrate overcolours in old cultures on dark tints. Primary conidia in cultures a little greater than from insects, 16-26 x 9-14, but of typical shape. Growth on PDA and biomalt-agar with pepton slower.

Distribution and host. Europe, on caterpillars of *Plutella xylostella* (L.), syn. *P. maculipennis* Curtis (*Lepidoptera*: *Plutellidae*). Until now not reported from Poland.

(29.) *Zoophthora brahminae* (Bose et Mehta) Batko

Zoophthora brahminae (Bose et Mehta) Batko Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 406; *Entomophthora brahminae* Bose et Mehta, Trans. Brit. Mycol. Soc. 36: 55. 1953; — *Zoophthora* subg. *Pandora brahminae* (Bose et Mehta) Batko ex Batko, Acta Mycol. 2: 19. 1966; — *Erynia brahminae* (Bose et Mehta) Remaudière et Hennebert, Mycotaxon 11: 302. 1980; — Erynia subg. *Neopandora brahminae* (Bose et Mehta) Re-

maudière et Hennebert ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 462. 1982; — *Pandora brahminae* (Bose et Mehta) Humber, Mycotaxon 34: 452. 1989.

Mycelium filling host's body cavity comprises elongate hyphal bodies of irregular shapes and longer septate hyphal segments. Conidiophores 8-9 mm thick, digitalely branched in typical way. Primary conidia ovoid, mostly 18-22 x 11-15 μm, with papillae moderately convex, about 4-7 μm wide; secondary conidia similar. Pseudocystidia undescribed. Rhizoids monohyphal, 14-24 μm wide, eextended at ends into holdfasts 100-160 μm wide with uneven margins. Resting spores hyaline to pale yellowish, globose, 22-39 (av. 29) μm in diam., with thick, roughly spinose epispore.

Distribution and hosts. India, in adult beetles of *Brahmina* sp. and *Anomala rufiventris* Redt. (*Col.*: *Scarabaeidae*).

Remarks. Conspecifity of this fungus with *Zoophthora echinospora* supposed by Humber and Ben-Ze'ev (1981: 511) seems to be very little probable because of high host specificity of the latter.

(30.) *Zoophthora bullata* (Thaxter et MacLeod in Humber) Bałazy ex Humber, n. comb.

Entomophthora bullata Thaxter in Povah, Pap. Michigan Acad. Sci. 20: 120. 1935 (nom. inval., basionym); MacLeod, Tyrrell, Soper et Delyzer, J. Invertebr. Pathol. 22: 75-79. 1973 (nom. inval.); — *Zoophthora* subg. *Zoophthora bullata* (Thaxter in Povah) Batko, Acta Mycol. 2: 18. 1966 (comb. inval.); — *Erynia bullata* (Thaxter in Povah) Remaudière et Hennebert, Mycotaxon 11: 302.1980 (comb. inval.); *Erynia bullata* Thaxter et MacLeod in Humber, Mycotaxon 13: 472. 1981; — *Pandora bullata* (Thaxter et MacLeod in Humber) Humber, Mycotaxon 34: 452. 1989.

Hyphal bodies polymorphic, becoming hypha-like after host death. Conidiophores digitately branched, forming pseudohymenial layer on host's abdomen and thoracical sutures. Primary conidia ellipsoid to ovoid 23-37.5 x 12-16.5 μm (av. 29.5x14 μm). Secondry conidia and pseudocystidia undescribed. Nuclei large, 6-10 μm. Rhizoids unbranched, hypha-like, without expanded holdfasts or branching at ends. Resting spores globose, yellow to light tan in mass, covered by thick wall with dense and prominent bullation on the epispore; total diameter of the resting spores — together with superficial protuberances 37-62 μm (ca. 50 μm).

Distribution and hosts. North America, Great Britain, on big calyptrate flies; identified host species — *Sarcophaga aldrichi* Parker (*Diptera*: *Sarcophagidae*), *Phormia regina* (Meigen), *Phaenicia sericata* (Meigen) (*Calliphoridae*).

Remarks. Batko (1966 a) treated this species as a representative of the subg. *Zoophthora*. According to the description given by Humber (1981) its rhizoids are hypha-like without spe-

cialized holdfasts, which does not suit to the H u m b e r' s (1989) diagnosis of the genus *Pandora*. Knowing, however, his exactness and prudence I believe that there were found sufficient characteristics for such an affiliation of *Z. bullata*.

31. *Zoophthora poloniaemajoris* B a ł a z y, n. sp.

D i a g n o s i s. *Corpora hyphalia elongata, irregulariter ramosa, vel ab ovatis usque ad ellipsoidalia, 25- ca 100 µm longa, 9.5-16.5 µm crassa. Conidiophora crassitudine 6-8 µm; cellulae conidiogenae claviformes, in dimensiones 22-30 x 8.5-10 µm. Conidia primaria in insectis formantia, dimensionibus 17.5-20.5 x 9.5-10.5 µm, oblongo-ovalia cum leniter arcuatis vel fere truncatis papillis, in cultura artificiali lato-ovalia cum semigloboso-convexis, magnopere angustis papillis, latitudine 2-3 µm. Pseudocystidia conica, 120-150 µm longa, ad basim 6-8 µm lata, supra usque ad 3-4 µm coartata. Rhizoidea pauca, monohyphalia cum specificis scutulis ad finem adhaerentibus. Sporae perdurantes ignotae. In larvis et imaginibus insectorum familiae Jassidae parasitans.*

H o l o t y p u s. *Specimen numero 2388 f designatum, die 27 mensis Iulii anno 1991 ad nympham Jassidae in silva frondosa* Jeziory, Wielkopolski Park Narodowy, *collectum, in praeparatione microscopica partim in hospite, partim ut cultura exsiccata depositum, in collectione* ZBS PAN.

Hyphal bodies elongate and irregularly ramose with loosely joined segments or ovoid to ellipsoid, 25 to about 100 µm long and 9.5-16.5 µm thick. Conidiophores 6-8 µm thick, typically branched; conidiogenous cells claviform, 22-30 x 8.5-10 µm. Primary conidia (Fig. 28c) oblong ovoid 17.5-20.5 x 9.5-10.5 µm, with slightly convex or almost truncate papillae. Secondary conidia similar, a little shorter. Pseudocystidia 120-150 µm long, 6-8 µm thick at the base, attenuating steadily towards blunt apex 3-4 µm wide. Rhizoids few in thoracical part, typical, with expanded holdfasts. Resting spores unknown.The cultures develop well both on media enriched with egg yolk and on SA and PDA, abundantly and typically sporulating. Both primary and secondary conidia broadly ovoid, rather short, of L:D ratios 1.5-1.7, with small but strongly protruding papillae 2-3 µm wide (Fig. 28m). General view — Fig. 29.

D i s t r i b u t i o n a n d h o s t. On the jassid leaf-hopper attached to the underside of a leaf of *Stachys silvatica* L., Wielkopolski National Park, Jeziory, Poland, collected on 5 August, 1985, and on a series of nymphys of an unidentified species of *Jassidae* under leaves of *Acer pseudoplatanus* L. found in the period 27 July and 10 August 1991 in the same locality.

R e m a r k s. The fungus show some typical resemblance to related species of the subgenus *Neopandora* as *Z. suturalis* (p. 200) *Z. myrmecophaga* (p. 188) and to *Z. muscivora* (p. 194). The only species of this subgenus reported hitherto from plant hoppers, *Z. dephacis* (p. 183), has much

Fig. 28. Conidia of some species of *Zoophthora* subg. *Neopandora*: a — *Z. vomitoriae* — primary conidia (from calliphorid flies: 2342 — Wielkopolski National Park, 2468 — Poznań, experimental frog rearing of the ZBS PAN; b — *Z. muscivora* — primary conidia (from flies, Wielkopolski National Park); c — *Z. poloniaemajoris*: p — primary conidia, s — secondary conidia, m — conidia from culture on PDA (from jassid plant hoppers, Wielkopolski National Park); d — *Z. phyllobii*: p — primary conidia, m — conidia from culture on SDEYA (from *Phyllobius* sp., Wielkopolski National Park).

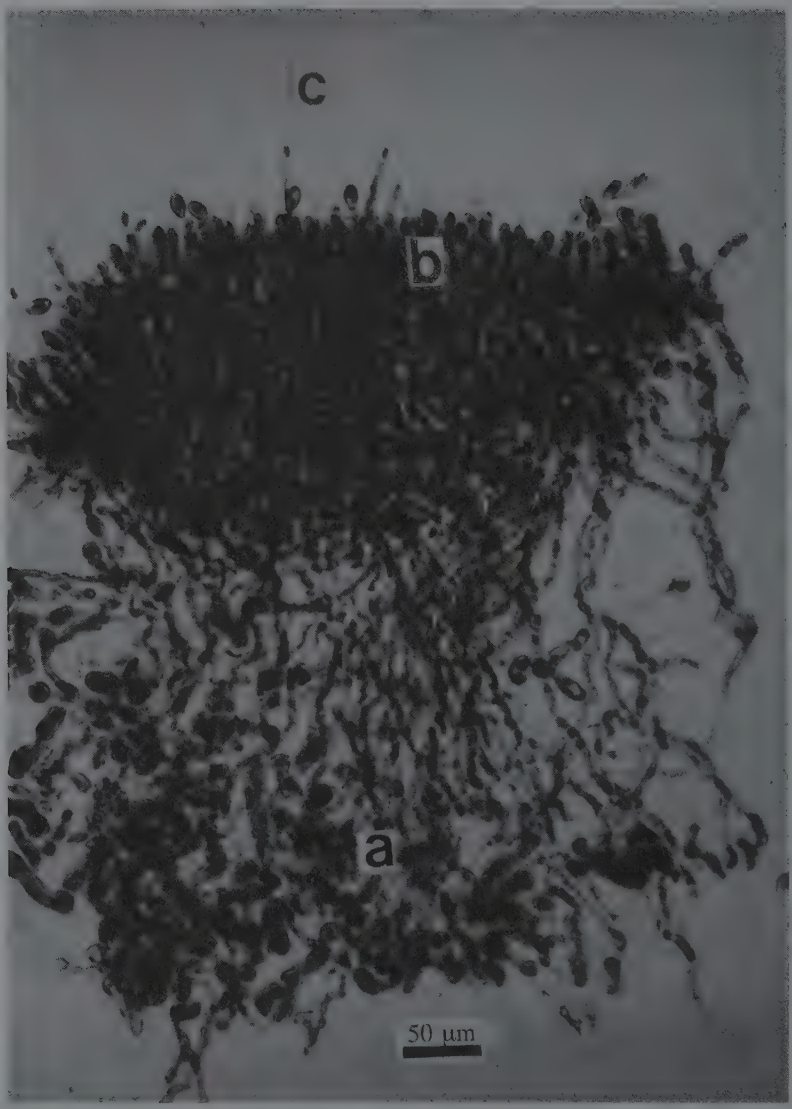


Fig. 29. *Zoophthora* subg. *Neopandora poloniaemajoris*. — aspect of mycelium in host: a — hyphal bodies intermixed with hyphae, b — pseudohymenial layer of conidiophores and conidiogenous cells, c — pseudocystidia.

greater primary conidia and does not form rhizoids. Good growth on media not containing egg yolk and round ovoid conidia in cultures differ it from other species of comparable morphology.

Etymology: Related to the Wielkopolska (Great Poland, Lat. *Polonia Major* region).

32. *Zoophthora dacnusae* (Bałazy) Bałazy, n. comb.

Erynia dacnusae Bałazy, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 19: 228-229. 1982 (basionym); *Pandora dacnusae* (Bałazy) Humber, Mycotaxon 34: 452. 1989.

Hyphae septate 6-10 µm thick, easily dividing into separate segments 20-50 µm long. Conidiophores 6-9 µm thick, dichotomously or digitately branched; terminal branches cylindric or clavate 15-30 x 9-12 µm. Primary conidia ovoid or ellipsoid, 19-24 (-27.5) x 11-13 (-15.2) µm, with slightly convex, small papillae 4.5-5.5 µm wide. Secondary conidia similar, smaller. Pseudocystidia conical about 150 µm long, 18 µm thick at bases and about 9 µm wide at obtuse tips. Rhizoids monohyphal numerous in thoracical and abdominal part of host's body, ribbon-like, 8-20 µm wide, ended with disc-shaped holdfasts of rugged margins. Resting spores unknown.

Distribution and host. Known only from the type locality in the Wielkopolski National Park near Poznań, Poland from a hymenopteran *Dacnusa* sp. (*Braconidae*).

(33.) *Zoophthora delphacis* (Hori) Bałazy ex Humber, n. comb.

Entomophthora delphacis Hori, Entomol. Mag.(Tokyo) 3:81. 1906, (basionym); Shimazu, Jap. Appl. Ent. Zool. 20: 144-150. 1976. — *Erynia delphacis* (Hori) Humber, Mycotaxon 13: 212. 1981; — *Pandora delphacis* (Hori) Humber, Mycotaxon, 34: 452. 1989.

Hyphal bodies as elongated hyphal segments, often somewhat blown and rounded at one or both ends. Conidiophores repeatedly dichotomously or digitately branched. Primary conidia ovoid to ellipsoidal 29.2-35.6 x 13-17.5 µm (ca. 32.7 ±1.3 x 14.8 ±1.4 µm) (Fig. 30), with rather small, convex papillae. Secondary conidia ovoid, shorter but wider, with papillae very narrow, often wart-like. Pseudocystidia needle-like conical, up to 300 µm, long about 10-15 µm thick at the base. Rhizoids lacking. Resting spores unknown.The fungus grows and sporulate well on many different media. Growth and conidiation on Sabouraud-agar enriched with egg yolk or extract from lepidopteran pupae more intense than on common SA. Primary conidia from cultures little smaller and more variable than those from insects, 22.9-36.8 x 12.4-20.3 µm (av. 30.2 3 x ± 1.5 ±1.7 µm).

Distribution and hosts. Eastern Asia, on the brown plant hopper *Nilaparvata lugens* (Stol.) (*Homoptera*: *Delphacidae*), artificially also infects some species of aphids. A fungus of

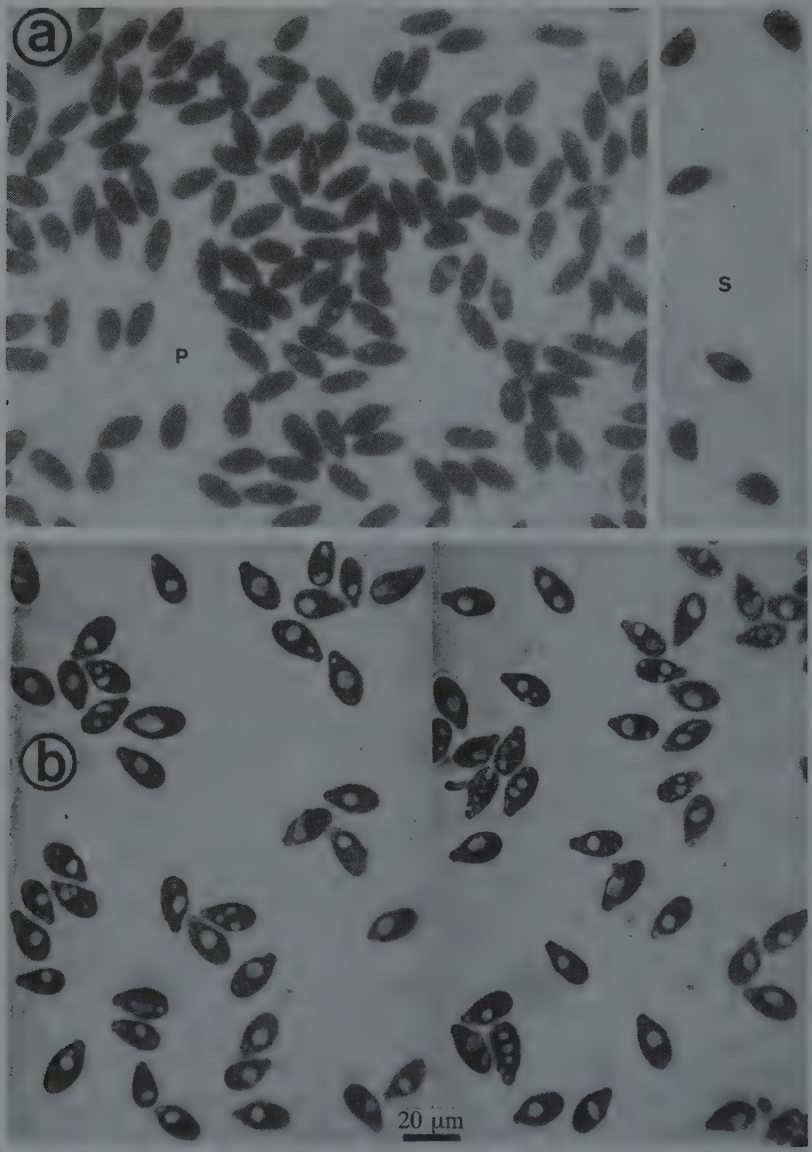


Fig. 30. Conidia of some species of *Zoophthora* subg. *Neopandora:* a — Z. cf. *dephalcis*: p — primary conidia, s — secondary conidia (Laufen, Germany) from a plant hopper, b — Z. *lipai* — primary conidia (from *Rhagonycha lignosa* Wielkopolski National Park).

identical morphology was lately found on a small specimen of *Auchenorrhyncha* in Bavaria (Federal Republic of Germany) on a grass stem in a meadow (leg. S. Bałazy).

34. *Zoophthora dipterigena* (Thaxter) Batko

Zoophthora dipterigena (Thaxter) Batko, Bull. Acad. Pol, Sci., Ser. Sci. Biol. 12: 405. 1964; *Empusa* subg. *Entomophthora dipterigena* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 177. 1888; — *Entomophthora dipterigena* Thaxterex Lakon, Z. angew. Entomol. 5: 179. 1919. — *Zoophthora* subg. *Pandora dipterigena* (Thaxter) Batko ex Batko, Acta Mycol. 2: 19. 1966; — *Erynia dipterigena* (Thaxter) Remaudière et Hennebert, Mycotaxon 11: 302. 1980; — *Erynia* subg. *Neopandora dipterigena* (Thaxter) Remaudière et Hennebert ex Ben-Ze' ev et Kenneth, Mycotaxon 14: 462. 1982; — *Pandora dipterigena* (Thaxter) Humber, Mycotaxon 34 (2): 452. 1989.

Mycelium inside hosts comprising of irregularely elongate hyphal bodies 12-20 µm thick and longer hyphae 8-15 µm in diam., often branched and sometimes easily fragmented. Conidiophores 6-9 µm thick, richly branched in top part. Primary conidia elongate, rather of not regular shapes, obtuse spindle-shaped to ellipsoid in outline, 22-30 x 11-15 µm, with semiglobose papillae 5-7 µm wide, distinctly protruding from the spore contour. Secondary conidia ovoid or somewhat pear-shaped shorter. Pseudocystidia conically needle-shaped, long, about 150-350 by 8-13 µm at the bases, narrowing to same 4-5 µm at obtuse tips, numerous — especially in early phases of conidiation. Rhizoids tubular or ribbon-like, with distinct and wide terminal disc-like holdfasts, numerous in thoracical and abdominal parts of body. Resting spores globose, smooth, hyaline, 20-40 µm in diam., produced on the surface of host insects in superficial mycelium.

Distribution and hosts. North America, Europe, on small nematocerous flies, mostly of the families *Tipulidae*, *Mycetophilidae* and *Sciaridae*.

Occurrence in Poland. Common in forest undergrowth and forest floor vegetation, in riparian bushes and wild plant associations; found also in a mushroom-growing in cellar on *Lycoriella solani* Winn. (*Diptera*: *Sciaridae*).

Remark. No specimens producing resting spores have been found in Polish material.

35. *Zoophthora echinospora* (Thaxter) Batko

Zoophthora echinospora (Thaxter) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 405; — *Empusa* subg. *Entomophthora echinospora* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 180. 1888; — *Zoophthora* subg. *Pandora echinospora* (Thaxter) Batko ex Batko, Acta Mycol. 2: 19. 1966; — *Pandora echinospora* (Thaxter) Humber, Mycotaxon 34: 452. 1989.

Mycelium filling host's body by dense network of strongly vacuolized hyphae of easily disjoining segments about 80-13- x 9-13 µm, usually conjugating (Fig. 31c). The hyphae growing through cuticle are rather evenly narrow, filamentous and tangled, about 7-8 µm thick, with some conjugating segments thicker, up to about 13 µm. Conidiophores about 7-9 µm thick, digitately branched. Primary conidia oblong ovoid, ellipsoid, or pyriform 20-25 x 10-14 µm with rather weakly convex papillae 5-7 µm wide. Secondary conidia reported by Thaxter (1888) as similar to the primary ones or differring only slightly, in Polish materials were mostly round ovoid of „*Entomophthora muscae*-type" (Fig. 31b) but monokaryotic, 13-17 x 7-10 µm. Pseudocystidia about 100-250 µm long, 12-15 µm thick at the base, slightly convergent towards the apex, occur only on specimens with conidial sporulation. Rhizoids numerous, monohyphal, protruding from host's abdomen and around the whole body, terminated by typical disc-like holdfasts, particularly those growing from abdomen. Zygospores spherical, 30-40 µm in diam., of strongly spinulose episporium, yellow to clay coloured in mass, sometimes with redish tint, produced both internally and externally on host insects.

Distribution and hosts. North America, Europe, on adults of *Sapromyza longipennis* Fabr. and other flies mostly or exclusively of the family *Lauxaniidae* (*Diptera*).

Occurrence in Poland. Wielkopolski National Park, common and often epizootic on *Lyciella decipiens* Loew, *L. rorida* Fallen, *L. subfasciata* Zetterstedt and probably some other unidentified species; single infected specimen has also been found in the Białowieża National Park — identified host species is *Minettia fasciata* Fallen (*Diptera*: *Lauxaniidae*). Two specimens preserved in Schroeter's collection at the Wrocław University Herbarium (WRLS) contain only resting spores not differing from those collected in Poland. Mostly resting spore state occur under natural condition, usually in the period of July-September.

Remarks. As regards morphology, host insects and circumstances of epizootics this American fungus behaves like aforedescribed Polish one and Central European species *Entomophthora lauxaniae* Bubàk (1903) for which, however, the conidial form remains undescribed. In relation to Thaxter's (1888: 180-181) description there are some differences stated in Polish specimens on which the above description has been based:

— the secondary conidia are regularly short ovoid with hardly marked apical points, almost truncate papillae and great single, round central vacuoles (compare Remaudière and Hennebert 1980: 308);
— pseudocystidia regularly occur in specimens producing conidial sporulation;
— conjugating hyphal bodies occur mostly inside host's body and the majority of zygospores is produced internally.

In my opinion both American, English and Swedish fungi as well as Central European ones are the same. Thus *Massospora richteri* Bresadola et Staritz, 1892, *Entomophthora lauxaniae* Bubàk, 1903 and all deriving from them nomenclatural combinations concern only resting spore state of *Z. echinospora*. This should be, however, confirmed by reexamination of Thaxter's and other accessible materials. Another synonym is probably *Entomophthora* (*Tarichium*) *pallida* Roivainen ex Liro.

Fig. 31. *Zoopthora* subg. *Neopandora echinospora*: a — primary conidia, b — secondary conidia of the „*Entomophthora*-like" type, c — successive stages of zygospore formation (from lauxaniid flies, Wielkopolski National Park).

36. *Zoophthora myrmecophaga* Turian et Wuest

Zoophthora myrmecophaga Turian et Wuest, Mitt. Schweiz. Entomol. Gesellsch. 50: 285. 1977, (nom. inval.); — Humber, Mycotaxon 13: 477. 1981; — *Entomophthora myrmecophaga* Turian et Wuest, Mitt. Schweiz. Entom. Gesellsch. 42: 197-201. 1969.

Erynia formicae Humber et Bałazy in Humber, Mycotaxon 13: 475. 1981; — *Erynia* subg. *Neopandora formicae* Humber et Bałazy in Humber ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 462. 1982; — *Pandora formicae* (Humber et Bałazy) Humber, Mycotacon 34: 452. 1989.

Hyphal bodies inside hosts have generally the appearence of hyphal segments of very differentiated dimensions, about 30-150 x 6-20 µm, with outgrowths, branches and yeast-like buds, giving rise typical, oligokaryotic hyphae. Conidiophores 6-8 µm thick, dichotomously or digitately branched at ends. Primary conidia ovoid or somewhat pyriform, 18-25 x 10-16 µm, with rather broad distinct papillae. Secondary conidia smaller, of the same shape. Pseudocystidia not numerous, typically hypha-like, not thicker than conidiophores, of weakly convergent sides towards ends, of different length from about 150 to even 400 µm in some specimens. Rhizoids few, ribbon-like, with expanded holdfasts, growing always as a loose bundle from thoracical host's underside. Resting spores unknown. Cultures on Sabouraud agar enriched with egg yolk obtained several times basing on material from only one locality (Racot near Poznań) — despite numeropus other attempts. Mycelium white with normal and typical sporulation. Colony growth slow; loss of vitality after about 6 months.

Distribution and hosts. Europe (Switzerland, Germany, Poland, Sweden, and former USSR, Yugoslavia, Czechoslovakia), on ants of the genus *Formica* (*Hymenoptera*: *Formicidae*); thoracical part of a small ant affixed to a leaf of forest floor plant by identical rhizoids and with few similar conidiophores and conidia was found near Hancock in USA (leg. S. Bałazy in 1991).

Occurrence in Poland. Surrounding of Poznań (Opalenica, Racot), Tuchola Forest, Notecka Forest, Białowieża Forest, Puławy near Lublin, Bieszczady Mts., Holy Cross Mts., on *Formica rufa* L. and *F. polyctena* Forst.

Remarks. The author of the present review was convinced on the conspecifity of *Z. myrmecophaga* and *Erynia formicae* and only incompletness of and vagueness in descriptions of the former (Turian & Wuest 1969, 1977) made impossible to ascertain officially such a synonymization; this has been done recently by Keller (1991).

37. *Zoophthora heteropteris* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia irregulariter ovata vel ellipsoidalia, circa 20-80 µm longa, 15-20 µm lata, cum segmentis hypharum, magis tenuibus, saepe ramosis, permixta. Conidiophora 6.5-8.5 µm crassa. Conidia primaria dimen-*

sionibus ex insectis (18-) 19-20 (-22.5) x 8.5-10.5 µm, *ex cultura 19.5-24.5 x 9.5-13.5* µm, *angusto-ellipsoidalia vel paulum claviformia, ad basim in brevissimum superpapillare collum, 4-4.5* µm *latum, statim coartata; papilla minime convexa. Conidia secundaria minora, cum distinctis papillis circa 3* µm *latis. Pseudocystidia conica 150-250* µm *longa, ad basim 8-12* µm *crassa fere aequo-angusta. Rhizoidea monohyphalia, crassitudine 10-14* µm, *reticularibus appendicibus e contextis irregularibus ramulis constantibus finita. Sporae durantes ignotae. In nympha insecti ordinis Heteropteris.*

Holotypus. *Specimen numero 2281 designatum, die 11 mensis Iunii anno 1989 in silva virginea Bialoviezensis (Polonia) collectum, in praeparatione microscpica et in cultura exsiccata depositum in collectione* ZBS PAN.

Hyphal bodies inside host ovoid or irregularly elongatead, bout 20-80 x 15-25 µm, with numerous outgrowths and hyphae mostly 5-11 µm thick. Conidiophores 6.5-8.5 µm thick, typically branched in top part. Primary conidia (18-) 18.7-20.3 (-22.5) x (8.5-) 9-10 (-10.5) µm, narrow ellipsoidal or somewhat clavate, slightly but abruptly narrowed at the base into very short over-papillar neck closed by hardly arcuate papillae 3-4 µm wide (Fig. 32a). Secondary conidia smaller, distinctly narrowing towards bases, with papillae distinctly convex, up to 3 µm wide. Pseudocystidia long, 150-250 µm long and 8-12 µm thick at bases, insignificantly narrowing towards obtuse tips. Rhizoids monohyphal 10-14 µm wide with raticulate holdfasts consisted of flat complex of irregular branchlets, very numerous, expanding obliquely far around host's body (Fig. 32d). Resting spores unknown.

The fungus grows and sporulate well in cultures on media containing egg yolk; 4 day old colonies attain 1.5-2 cm in diam., cream-white of waxy, compact surface bristled with numerous pseudocystidia. Intensive conidiation between 4-thand 8-th days of culturing at the temperature about 20°C. Primary conidia of stronger differentiated dimensions, 19.5-22.5 (-24.8) x (9.4-) 10-13 (13.5) µm, with papilla indistinct or epapillate (Fig. 32c).

Distribution and hosts. On a small nymph of unidentified bug (*Heteroptera*) attached to the underside of a leaf in forest undergrowth, Białowieża National Park, collected on 11 June, 1989. Microscopic prepared slide containing remainings of the insect body and elements of mycelium with primary and secondary conidia has been designed as the type (number 2281 in collection).

Remark. The primary conidia are unlike to other known species of the subgenus *Neopandora*. There are few reports of fungi showing features of this subgenus affecting heteropterous bugs. Thaxter (1888: 177) found such a pathogen related to *Z. neoaphidis* or *Z. dipterigena* on a big bug specimen, probably of the family *Corsidae*, however, he did not give any exact description.

Etymology: *Heteroptera* — host's insect order name.

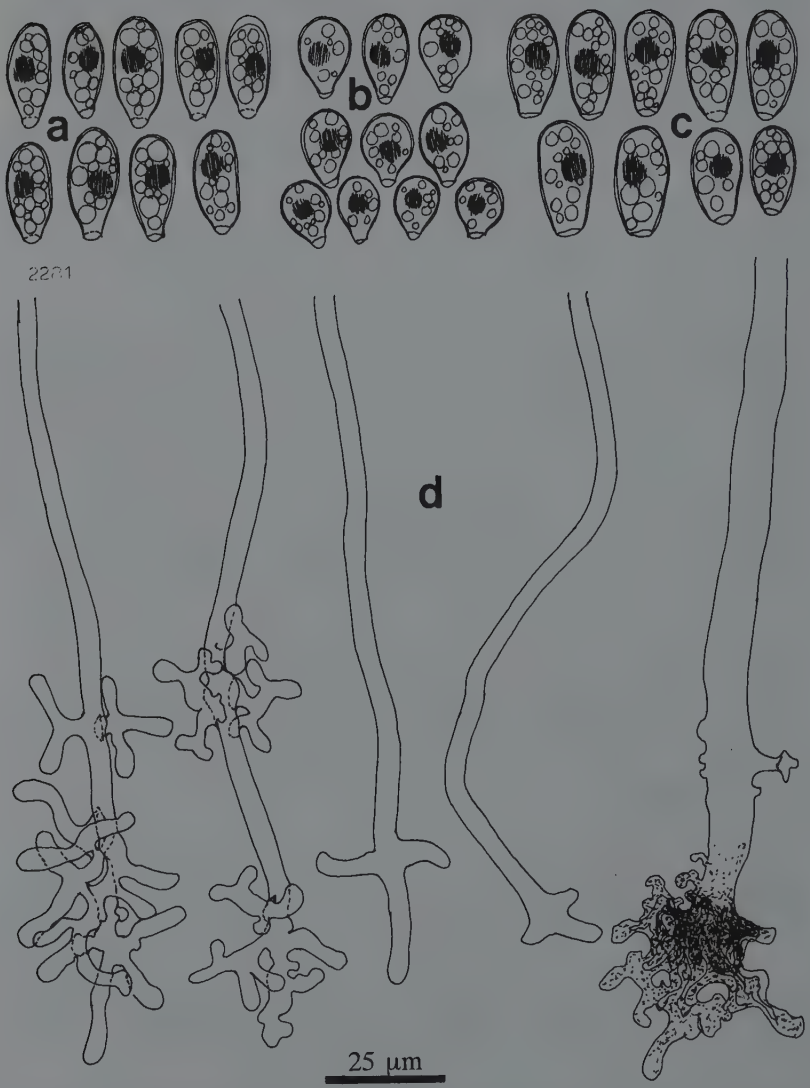


Fig. 32. *Zoophthora heteropteris*: a — primary conidia, b — secondary conidia, c — conidia from culture on SDEYA, d — terminal parts of rhizoids around the abdominal part of infected insect (from a nymph of *Heteroptera*, Białowieża National Park).

(38). *Zoophthora gloeospora* (Vuillemin) Batko

Zoophthora gloeospora (Vuillemin) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 406. 1964; — *Entomophthora gloeospora* Vuillemin, Bull. Soc. Sci. Nat. Nancy, Ser. 2, 19: 34-36; 1886; — *Zoophthora* subg. *Pandora gloeospora* (Vuillemin) Batko Acta Mycol. 2: 19. 1966; — *Erynia gloeospora* (Vuillemin) Remaudière et Hennebert, Mycotaxon 11: 302. 1980; — *Erynia* subg. *Neopandora gloeospora* (Vuillemin) Remaudière et Hennebert ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 462. 1982; — *Pandora gloeospora* (Vuillemin) Humber, Mycotaxon 34: 453. 1989.

Mycelium inside host insect filamentous, branched; the hyphae fragmenting into spherical or somewhat irregular hyphal bodies, after Vuillemin's (1886) drawing about 70 µm long and 25 µm thick, containing ellipsoid nuclei 9 x 4.5 µm, often with thinner outgrowths and ramified hyphae. Conidiophores about 10 µm thick, bifurcately branched, with sporogenous cells clavate, about 15 µm thick in upper part. Primary conidia broadly ovoid, ca 20 x 14 µm, with papilla rather flat arcuate, not protruding abtuptly from the spore outline, about 6.5-7 µm wide; their outer walls often strongly distanced from the inner ones by transparent, formless layer; nuclei in the conidia 4 x 5 µm. Pseudocystidia unmentioned in descriptions but the figures 3 and 4 strongly suggest their presence, although Vuillemin (1886) seems to misinterpret them as affixing structures („les tubes fixateurs"). As recalculated from the drawings they are about 20 µm thick at the base, conically uniformly attenuating upwards. Rhizoids present but their structure undescribed. Resting spores uninucleate, globose, 24-41 µm (mostly 35 µm) in diam., surrounded by walls 4-6 µm thick, uncoloured, smooth, produced laterally or interstitially from hyphal cells; nuclei in the resting spores 5-7 µm in diam.

Distribution and hosts. Europe (France) on *Mycetophila* sp. (*Diptera*: *Mycetophilidae*), North America – USA (Pennsylvania), on *Lycoriella mali* (Fitch) (*Dipt.*: *Sciaridae*).

Remarks. Taking into consideration thickness of pseudocystidia and lack any notice about rhizoid holfasts this fungus may be a representative of the subgenus *Erynia,* however Miller and Keil (1990) maintained its position in Humber's genus *Pandora.*

39. *Zoophthora ithacensis* (Kramer) Bałazy, n. comb.

Erynia ithacensis Kramer, Mycopathologia 75: 160-164. 1981 (basionym); *Erynia* subg. *Neopandora ithacensis* Kramer ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 462.1982; — *Furia thacensis* (Kramer) Humber, Mycotaxon 34/2/: 451.1989.

Host body filled with irregularly ovoid, ellipsoid or elongate hyphal bodies 25-120 x 18-27 µm, sometimes slightly inflated at ends, intermixed with regular hyphae 5-10 µm thick. Conidiophores 6-8 µm thick, irregularly digitately branched in top part. Primary conidia narrow ovoid to ellipsoid, 15-24 x 8.5-12 µm, with

rather broad papilla 5.5-7 μm wide, arcuately protruding from the spore outline. Secondary conidia ovoid of smaller L:D ratio. Pseudocystidia up to about 250 μm long, 8-13 μm thick at the level of conidiogenous layer, steadily tapering to about 5-6 μm at tips. Rhizoids monohyphal, numerous, ended with flat networks of more or less dense irregular branchlets, forming the holdfasts of approximately round outline. Resting spores spherical 26-41 μm in diam., towny to rusty brown in mass, surrounded by light yellow walls about 5 μm thick, with irregularly rugose and ridged, darker yellow or brown epispore.

The fungus grow well on artificial agar media enriched with egg yolk. On SAEY colonies attain the diameter 1.5-2 cm in a week. Mycelium is at first white and somewhat floccose, transcolouring quickly into cream-yellow or light brownish, surface waxy consisting of dense layer of conidiophores. Conidia produced on media do not differ from those on insects. Submerged mycelium darken with age together with surrounded substrate. Resting spores were seldom produced in the author's cultures.

Distribution and hosts. North America (North Eastern States) of USA, Central Europe (Poland), on a number of brachycerous flies mostly of the families *Rhagionidae* and *Empididae*.

Occurrence in Poland. Białowieża Forest, Wielkopolski National Park, deciduous and mixed forests, on flies attached to the underside of leaves in forest undergrowth, from the end of May till September, common species. Identified host species: *Rhagio conspicuus* Meigen, *R. mystaceus* L., *R. scolopaceus* L., *Symphoromyia* sp. (*Rhagionidae*), *Platypalpus* sp. (*Empididae*).

Remarks. One can suppose that in the past this species was not distinguished from other related species infecting flies, such as *Z. dipterigena*, *Z. muscivora*. For instance Batko in 1965 reported and included into his keys for identification a species *Z. dipterigena* ssp. *parva*, ssp. nov., separated on the basis of smaller and more uniform conidia. Because this part of Batko's dissertation thesis has not been published the aforementioned taxonomical proposal has been generally remaining unknown.

40. *Zoophthora lipai* Bałazy, Eilenberg et Papierok, n. sp.

Diagnosis. *Corpora hyphalia elongata, dimensionibus 50-70 x 7-12 μm, raro cum ramis irregularibus. Hyphae 8-15 μm crassae. Conidiophora 7-10 μm lata, in apice digitose ramosa; cellulae conidiogenae cylindratae vel leniter clavatae, dimensionibus 20-28 x 8-11.5 μm. Conidia primaria elongato-ovoidea vel brevi-claviformia, dimensionibus (18.5-) 19.5-23 (-24) x (8.5-) 9-10.5 (-11) μm, cum papillis 4-5 μm latis. Conidia secundaria breviora, sed crassitudine primariis aequa. Pseudocystidia numerosa, conica, 150-250 μm longa — ad basim 10-17 μm, in apice 4.5-7 μm lata. Rhizoidea monohyphalia cum scutulis adhaerentibus terminata. Sporae perdurantes solite in culturis artificialibus formantes, globosae,*

in diametrum 20-33 µm, cum parietibus avellano-brunneis, 2.3-3 µm crassis, tenere asperis. In imaginibus Cantharidarum (Coleoptera) parasitans.

Holotypus. *Specimen numero 2358 designatum, in silva mixta* Jeziory *in* Wielkopolski Park Narodowy, *die 14 mensis Iunii anno 1991 ad Rhagonycha lignosa collectum, in praeparatione microscopica cum imagine exsiccata et cultura depositum in collectione* ZBS PAN.

Hyphal bodies as irregularly elongate segments of hyphae 50-70 x 7-12 µm, sometimes branched, intermixed with hyphae of rather uneven width 8-15 µm. Conidiophores 7-10 µm thick, richly branched. Primary conidia narrow ovoid to somewhat clavate, (18.5-) 19.5-23 (-24) x (8.5-) 9-10.5 (-11) µm, with slightly convex papillae 3.8 to about 5 µm wide (Fig. 30b). Secondary conidia ovoid, shorter but of similar thickness, 14.5-17.5 x 8.5-10.5 µm, stronger narrowing towards the base closed by semispherical papillae 2.5-3.5 µm wide. Pseudocystidia (Fig. 10a) numerous oblong conical, 150-250 µm long, 10-17 µm thick at the level of conidiogenous layer, 4.5-7 µm thick at the blunt tips. Rhizoids monohyphal, ribbon-like, these growing from the central area of hosts's ventral side are terminated with wide, flat disc-like holdfasts of uneven margins, whereas those growing obliquely around host's body hare groups of irregular branchlets and outgrowths at ends. Resting spores, known only from artficial cultures, regularly globose, 20-33 µm, with the walls 2,3-3,0 µm thick of hazel brown, minutely rough epispore.

The fungus grows and sporulate well on artificial media containing egg yolk. One week old colonies are round 2-3 cm in diam., of the surface dirty white, at first floccose, becoming waxy since 4-5th day, when the conidiation begins. Conidiophores typically branched, primary and secondary conidia do not differ from these from insects. Resting spores appear after 3-4 weeks of culturing at the temperature about 20°C.

Distribution and hosts. On cantharid beetles *Cantharis livida* L., *C. rustica* Fallen, *Malthinus flaveolus* Paykull, *Rhagonycha lignosa* Müller and a small unidentified species, commonly occurring in the Białowieża Forest and Wielkopolski National Park from last decade of May till half of June. Recently also found in Denmark (leg. J. Eilenberg) and in France (leg. B. Papierok).

Remarks. The specimens of entomophthoralean fungi infecting adult beetles of *Cantaris* spp. collected in Great Britain were identified by Petch (1947) as „*Entomophthora anglica*" Petch, together with others affecting beetles in general. Revision of some Petch's materials has shown, that the first dated „*E. anglica*" is conspecific with *E. elateridiphaga* (Turian) Remaudière et Hennebert (1980) whereas other fungi on different beetles show some heterogeneity in these collections (Ben-Ze'ev 1986, 1987). One can suppose on this basis, that Petch's fungi from *Cantharis* sp. may represent the here described species.

Etymology: The name dedicated to author's friend, Professor Dr. Jerzy J. Lipa.

41. *Zoophthora muscivora* (Schroeter) Bałazy, n. comb.

Entomophthora muscivora Schroeter, Kryptogamen-Flora von Schlesien, III, 14 Lief.: 223. 1986 (basionym).

Host's body filled with branched hyphae of uneven thickness up to 24 µm. Conidiophores 7-10 µm thick, digitately branched, forming a dense, white cream layers on the surface of insect body; sporogenous cells claviform, up to 13 µm in diam. Primary conidia ovoid with blunt papillae of the convexity smoothly emerged from the spore outline, 20-24 x 11-13 µm (Fig. 28b). Secondary conidia similar, smaller. Pseudocystidia not observed. Rhizoids monohyphal, ribbon-like, expanded at ends into disc-like holdfasts of uneven outline. Resting spores globose, 24-28 µm in diam., of chestnut brown, smooth epispore.

Distribution and hosts. Western and Central Europe Great Britain, on big, probably brachycerous flies.

Occurrence in Poland. Silesia (Schroeter's reports), Świdnik near Lublin (Batko 1964a: 130, as „*Entomophthora calliphorae*" Giard, understood as synonym of *E. muscivora* Schroeter; a number of brachycerous flies infected with the fungus of identical conidia were collected in the Wielkopolski National Park (leg. S. Bałazy) and in Kolno (leg. Wanda Pieś and misidentified by her as *Entomophthora muscae* Cohn (specimen Nr 025318 in WA Herbarium), however no resting spores occurred in these materials. Batko (1964a) identified his material after Lakon's (1919) description which has been based on Schroeter's (1889) original diagnosis. In the Wrocław University Herbarium (WRSL) there has been preserved one specimen of rather strongly deteriorated calliphorid fly overgrown by an entomophthoraceous fungus, with the print „Schroeter Herbarium" on the cover and hand made by pencil notice "*Entomophthora muscivora?*, Rest sparse conidia", but without any label. It is excluded that this note could be Schroeter's one. The mycelium contains much bigger, oblong ovoid conidia, 27-38 x 14-16 µm, with 8-9.5 µm wide papillae, and unripe, hyaline resting spores 29-41 µm in diam., of the walls 2-3 µm thick. These structures resemble rather *Zoophthora vomitoriae* (see p. 201).

Remarks. Since the moment of the description this species was suspected to be conspecific with „*Entomophthora calliphorae*" Giard for the reasons of similarity of the resting spores, host attachment by rhizoids and occurrence on related host insects. This view has been indiscriminately sustained until recently (Thaxter 1888: 188, Lakon 1919: 175, Batko 1964a: 130, e: 405, Humber 1989: 452) although nobody has verified Schroeter's suggestion on possible identity of these two species by rediscovering infected specimens of *Calliphora vomitoria* L. with simultaneous conidial and resting spore sporulation or by a demonstration of any real range of the resting spore measurement and colour variability. It is only Petch (1948) who has identified „*Entomophthora muscivora*" Schroeter in a number of his samples from Great Britain, collected mostly in late summer and the fall. While discussing some aspects of application of the resting spore morphology as taxonomical criterion within *Entomophthorales* Remaudière and Hennebert (1980: 303) and Ben-Ze'ev and Kenneth (1982: 463-465) have indicated justifiable reasons to keep prudency in the treatment of fungi known only from their resting spore stage as conspecific with others, producing both conidia and similar but not entirely identical resting spores. For this reason these two forms have been treated here as separate, at least until thorough comparative studies are accomplished. Moreover, on the basis of strong differentiation of entomophtho-

ralean fungi collected until now on adult flies and observed host specificity of some forms one can suppose that the species range of these pathogens infecting dipterans may be in reality wider than hitherto reported.

42. *Zoophthora nouryi* (Remaudière et Hennebert) Ben-Ze'ev et Kenneth

Zoophthora nouryi (Remaudière et Hennebert) Ben-Ze'ev et Kenneth, Phytoparasitica 9 (1): 40-41. 1981; — *Erynia nouryi* Remaudière et Hennebert, Mycotaxon 11: 313-316. 1980; — *Erynia* subg. *Neopandora nouryi* Remaudière et Hennebert ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 462. 1982; — *Pandora nouryi* (Remaudière et Hennebert) Humber, Mycotaxon 34: 453. 1989.

Hyphal bodies irregularly elongate, often branched 90-180 x 6-10 µm, containing granular protoplasm and nuclei 4-6 µm in diam. Conidiophores typically ramose, occur on infected host insects as sporodochium-like aggregations. Primary conidia ovoid, (12-) 15-16.5 (-20) x (7-) 8-10.5 (-12) µm, with relatively wide and indistinctly convex papillae, smoothly coming into conidium outline. Secondary conidia undescribed. Pseudocystidia cylindric with obtuse ends, 70-140 x8-11 µm. Rhizoids monohyphal with distinct disc-like expansion at end, usually not developed on insects filled with resting spores. Resting spores hyaline, smooth, globose, (20-) 20.5-30.5 (-36) µm in diam., with walls 3-4 µm thick; residual hyphal body walls usually visible as appendices at foramen.

The fungus develops in cultures on media containing EY. Gustafsson (1965, after Remaudière and Hennebert 1980) has obtained both primary conidia and resting spores in cultures. The primary conidia from cultures were a little greater than from insects.

Distribution and hosts. Central, Northern and Western Europe, Israel, on the aphids *Pemphigus bursarius* L., *Aphis fabae* Scopoli and *Aphis umbrella* Börner; the first is considered as the typical host.

Occurrence in Poland. Szczecin voivodship, on *P. bursarius* (leg. I. Majchrowicz), Siedlce suburban gardens, on *P. phenax* Börner (leg. Miętkiewski).

Remark. Until 1980 the species was not separated from collections identified as „*Entomophthora aphidis*" in the sense of *Zoophthora* subg. *Neopandora neoaphidis* or as „*Entomophthora exitialis*". Particular considerations have been published by Remaudière and Hennebert (1980).

(43). *Zoophthora kondoiensis* (Milner) Bałazy, n. comb.

Erynia kondoiensis Milner in Milner, Mahon et Brown, Austral. J. Bot. 31: 183. 1983 (basionym); *Pandora kondoiensis* (Milner) Humber, Mycctaxon 34: 453. 1989.

Hyphal bodies up to 200 µm long and sometimes with irregular branches. Conidiophores distally somewhat swollen and digitately branched. Primary conidia from insects (14-) 16-21 (-29) x (7-) 10-12 (-16) µm, from cultures (13-) 17-23 (-29) x (8-) 11-14 (-21) µm, narrow ellipsoid, with rather thin and strongly protruded overpapillar neck, about 5-6 µm wide. Secondary conidia smaller ovoid or short pyriform. Pseudocystidia rather thin, hypha-like, little narrowing towards the obtuse apex. Rhizoids monohyphal ended with disc-like, irregularly lobate holdfasts. Resting spores unknown.

Growth and sporulation in artificial cultures good at the temperature range 5-20°C, poor at 25°C, none at 30°C. The dominant fatty acids in the mycelium are C12:O (24-46%) and usually C10:0, C14:0 and C16:0 (10-12%).

Distribution and hosts. Australia, on *Acyrtosiphon kondoi* Shinji, artificially also infected *A. pisum* (Harris), *Therioaphis trifolii* (Monell) f. *maculata* Buckton, *Hyperomyzus lactucae* (L.) and *Myzus persicae* (Sulzer).

Remarks. This species belongs to the aphidicolous group closely related to *Z. neoaphidis*. Apart from differences in the morphology and fatty acid content it may be distinguished from *Z. neoaphidis*, *Z. nouryi* and *Z. delphacis* by specific enzyme mobility (Milner et al. 1983).

44. *Zoophthora phalangicida* (Lagerheim) Batko

Zoophthora subg. *Pandora phalangicida* (Lagerheim) Batko, Acta Mycol. 2:19.1966; — *Empusa* subg. *Entomophthora phalangicida* Lagerheim, Bihang. Svensk. Vetenskapsk. Akad. Handl. 24: 12-15. 1888; — *Erynia phalangicida* (Lagerheim) Remaudière et Hennebert, Mycotaxon, 11: 302. 1980; — *Erynia* subg. *Neopandora phalangicida* (Lagerheim) Remaudière et Hennebert ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 462. 1982; — *Pandora phalangicida* (Lagerheim) Humber, Mycotaxon 34: 453.1989.

Mycelium inside hosts body in form of elongated, often branched hyphal segments 6-12 µm thick, intermixed with elongate and sparsely septate hyphae of the same width. Conidiophores about 10 µm thick, richly digitately branched in top parts. Primary conidia ovoid (Fig. 33) (18-) 20-22 x 10.5-12.5 µm, with slightly convex papillae 4.5-6 µm wide. Secondary conidia shorter 14.5-19 x 10-12 µm, stronger narrowing towards semispherically convex papillae 3.8-4.7 µm wide. Pseudocystidia numerous, conical, 250-350 µm long, about 18 µm thick at the level of conidiogenous layer, tapering steadily to about 8 µm below slightly inflated tips. Rhizoids numerous monohyphal, ribbon-like of the width 8-20 µm, terminated with typical disc-like holdfasts, growing down from ventral side of host's body and sometimes from junctions of legs.

Distribution and hosts. Central and Northern Europe (Sweden, Poland), reported from harvest spiders (*Opliliones*) and in one case, from the parasitid mite *Pergamasus septentrionalis* (Oudemans) (*Acarina*).

Fig. 33. *Zoophthora* subg. *Neopandora phalangicida* — primary (P) and secondary (S) conidia (from a harvest spider, Turew).

Occurrence in Poland. Siedlce, Turew near Poznań — on harvest spiders, Wielkopolski National Park — on the mite (see „Remarks" below and Bałazy & Wiśniewski, 1984).

Remarks. Presented above characteristics have been based mainly on Lagerheim's (1898) describtion, supplemented only with data concerning intramatrical mycelium and some dimensions on the basis of Polish materials. However, micromorphology of particular specimens of the latter differ also in some extent as follows:

Sample 1088 — from *Pergamasus septentrionalis*, Wielkopolski National Park. Primary conidia ellipsoid to oblong ovoid of the maximal width in about half of total height (18-) 20-22 (-24.5) x 10.5-12.5 µm, papillae slightly convex 5-6 µm wide. Secondary conidia ovoid to pyriform 14-18.7 x 10.5-12 µm, the thickest in the center; papillae semiglobose 3.2-4.7 µm wide. Rhizoids typical, ribbon-like 14.8-27.3 µm wide, with disc-like holdfasts. Observed unripe resting spores were round, 27-36 µm, of walls about 0.5 µm thick. The identification of this strain as *Z. phalangicida* is doubtful, but despite frequent search further materials have not been found.

Sample nr 2200 — from a harvest spider collected in Siedlce (leg. R. Mietkiewski). Primary conidia 19.5-23 x 9-9.5 (-10) µm, narrow ellipsoid or with the lower half conically attenuating into weakly convex papilla 3-4 µm wide. Secondary conidia ovoid, seldom longer than 15 x 8-11 µm, with small, strongly convex wart-like papillae 2.8-3.5 µm wide. Rhizoids typical ribbon-like of different width, sometimes growing also from leg junctions. Resting spores lacking.

Sample 2160 — from a harvest spider collected in Turew near Leszno. Primary conidia claviform of almost straight side lines, 21-25 x 8.5-10 µm, of the greatest diameter at 2/3 to 3/4 of total height; papillae slightly convex 4-5.5 µm. Secondary conidia pyriform, broad ovoid, 11-19 x 11-13 µm, the thickest above the center; their papillae semiglobose 3-4.5 µm wide (Fig. 33). Rhizoids lacking.

These observations indicate a necessity of further studies on *Zoophthora* species infecting harvest spiders and possibly other araneids to establish a real scope and host range of entomophthoralean fungi pathogenic for them.

45. *Zoophthora philonthi* Bałazy, n. sp.

Diagnosis. *Mycelium coenocyticum insecti corpus hyphis diametro 7.5-10.5 µm., rarissime septatis implet. Inter hyphas multa corpora hyphata ovoidea*

aut oblonga, dimensionibus 40-250 x 15-35 µm., interdum ramosa, pullulantia aut septata in angustioribus partibus. Conidiophora inter thoracis et abdominis partes duras fasciatim crescunt, etiam in capite circa peristoma atque in antennarum basi, in insecti corporis superficie valde ramosi fiunt et efficiunt stratum spissum sporas creans; rami terminales ovales aut ampullacei circa 25 x 13 µm. Conidia primaria (19-)-21-26 (-28) x (10.5-) 11-14 (-14.5) µm, subpapillata, ellipsoidalia aut ovoidea cum papilla ad instar hemisphaerae conformata, ad basim in papillam versus paule angustiora, apice regulariter rotundata, uninucleata cum multis imparibus vacuolis et cum duplici membrana. Conidia secundaria a primariis dimensionibus tantum minoribus differunt. Pseudocystidia sparsa, 70-120 µm longa, crassa ad basim 10-14 um, in apice 7-9 µm. Rhizoidea singularia, 8-10 µm crassa, cum paucis irregularibus ramificationibus, orbiculatis scutalibus pedibus diametro 20-40 µm., reticulatis, terminata.

Holotypus: *Specimen numero 1950 in collectione* ZBS PAN *designatum, a Philontho sp. ad stirpem plantarum affixo in cultura Medicaginis prope* Turew *(Polonia occidentalis) die 25 mensis Augusti anno 1987 collectum, atque in praeparationibus microscopicis asservatur.*

Host's body filled with irregularly elongate hyphal bodies 40-250 x 15-25 µm, sometimes ramose or budding, intermixed with almost parallelepipedous hyphae 7.5-10.5 µm thick, sparsely septate. Conidiophores 7-9.5 µm thick, richly branched, grow in intersegmental junctions, mouth parts and between articles of legs and antennae; terminal conidiogenous cells mostly flask-shaped about 25 x 13 µm. Primary conidia ellipsoid, (19-) 21-26 (-28) x (10.5-) 11-14 (-14.5) µm, rarely ovoid, slightly but abruptly narroved at the bases forming very short overpapillar neck (Fig. 34); papillae of rather distinctly arcuate outline or semiglobose, 5-6.5 µm wide. Secondary conidia similar, mostly ovoid, smaller. Pseudocystidia few scattered in areas of intensive conidiation, rather short — up to 120 µm long and about 10-14 µm thick at bases, unmarkedly tapering to obtuse tips or almost equally narrow. Rhizoids monohyphal, ribbon-like, 8-10 µm wide, terminated with irregularly round reticulate hold-fasts 20-40 µm in diam., grow mostly in thoracical part of host's body. Resting spores unknown.

Distribution and hosts. On staphylinid beetles *Philonthus* sp. in a coniferous forest, Porażyn near Nowy Tomyśl on 15 September 1974, a meadow in the Warta River Valley near Mosina (near Poznań) (leg. E. Baraniak) and in an alfalfa field in Turew, near Leszno on 25 August, 1987. The latter material (3 prepared slides and dry insect overgrown by sporulating mycelium signed with the number 1950) has been indicated as the holotype.

Remark. Staphylinid beetles of the genus *Philonthus* affected by entomophthoroses have been reported by Petch (1944, 1948), who identified the pathogen as „*Entomophthora anglica*". Since this name in the combination *Zoophthora* subg. *Zoophthora anglica* (Petch) Ben-Ze'ev should only be applied for entomophthorosis of elaterid beetles *Agriotes* spp. (Ben-Ze'ev 1986 a) the situation of aforedescribed species is analogous as in case of *Zoophthora lipai* (p. 192). The

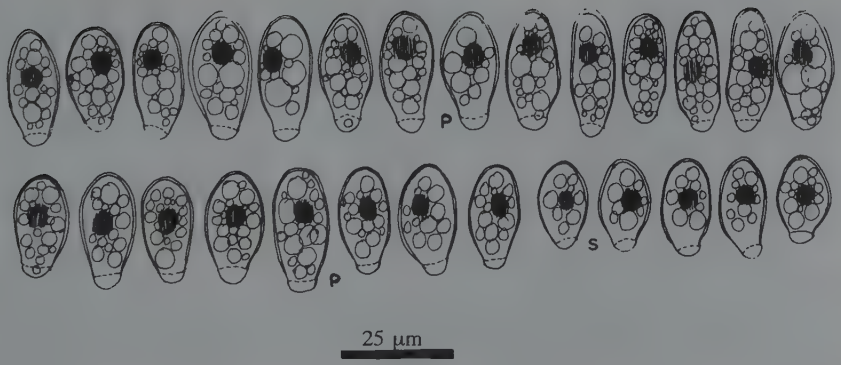


Fig. 34. *Zoophthora* subg. *Neopandora philonthi*: P — primary conidia from an adults of *Philonthus* sp. (upper row — Turew, beneath — forest distrinct Porażyn), S — secondary conidia.

fungus differs from the latter by distinctly ellipsoid shape of the primary conidia which are regularly thicker, and by inconspicuous pseudocystidia, different host insects, habitats and time of appearance.

Etymology: *Philonthus* — host species generic name.

46. *Zoophthora phyllobii* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia elongata, diversiformia, saepe ramosa, dimensionibus ca 20-130 x 7-21 µm. Conidiophora 6.5-9 crassa, in apice ramosa; cellulae conidiogenae cylindratae vel paulo clavatae, dim. 22-28 x 10-12.5 µm. Conidia primaria anguste ovoidea 19.5-23 x 10-11.5 µm vel ellipsoidalia dim. 23-31 x 11.5-14.5 µm, in parte basali conice attenuata in papillam ca 4 µm latam. Conidia secundaria breviter ovoidea vel fere sphaerica cum papilla minima fortiter convexa. Rhizoidea monohyphalia scutulis latis cum marginibus inaequalibus terminata. Pseudocystidia 180-400 µm longa, ad basim 9-11 µm crassa, in apice paulo attenuata. Sporae perdurantes ignotae. In imagine Coleopterorum Phyllobius sp. (Curculionidae) parasitans. In cultura artificiali cito augetur et sporas format. Mycelii color albus, deinde pallido-fulvus; coloniae per 7 dies ad diametrum ca 2.5 cm perveniunt. Quamquam papillae in culturis recta formabantur, conidia e cellulis conidiogenis non iaciebantur.*

Holotypus. *Specimen numero 2360 in collectione* ZBS PAN *designatum, in silva mixta prope* Puszczykowo (Wielkopolski Park Narodowy) *die 25 mensis Iunii anno 1991 collectum (*leg. S. Bałazy*).*

Hyphal bodies elongate of rather irregular shapes, often with branches or outgrowths, about 20-130 x 7-21 µm. Conidiophores 6-9.5 thick, typically branched

in apical part; conidiogenous cells cylindrical or clavate, 22-28 x 10-12.5 μm. Primary conidia (Fig. 28d-P) narrow ovoid, 19.5-23 x 10-12.5 μm, or ellipsoid, 23-31 x 11.5-14.5 μm, with the basal part conically attenuated towards small papilla, about 4 μm wide. Seconadry conidia short ovoid or almost subglobose, with small papillae rather strongly protruding. Rhizoids monohyphal with terminal disc-like holdfasts of unevenly sinuose margins. Pseudocystidia 180-400 μm long, 9-11 μm wide at the base, slightly attenuate upwards. Resting spores unknown. In adult beetles *Phyllobius* sp. (*Curculionidae*).

Cultures grow and sporulate well on media containing EY. Colonies at first white, after 5-7 days become cream to dirty-yellow, attaining about 2.5 cm in diam., in 7 days at the temperature 20°C. Despite normally formed papillar structure conidia in cultures (Fig. 28d-M) were not thrown away from the conidiogeous cells.

Distribution and hosts. Poland, Białowieża National Park and Wielkopolski National Park. Rare species, found only 3 times, despite every-year search in abundant host's populations. All specimens found in June.

Entymology: *Phyllobius* — host's generic name.

(47). *Zoophthora suturalis* (Ben-Ze'ev) Bałazy, n. comb.

Erynia subg. *Neopandora saturalis* Ben-Ze'ev, Mycotaxon 28: 405. 1986; — *Pandora suturalis* (Ben-Ze'ev) Humber, Mycotaxon 34 (2): 453. 1989.

Insect's body filled with hyphal segments or elongate ovoid hyphal bodies 20-40 x 7-12 μm and normal, sparsely septate hyphae, 4-8 μm thick. Conidiophores 7-9 μm thick, somewhat widened toward tips up to 10-11 μm, normally rather richly branched; terminal branchlets bottle- or shittle-shaped, 20-30 x12-15 μm. Primary conidia ovoid, rerely ellipsoid, 18.7-22.5 x 10.7-14 μm, with slightly convex papillae usually not protruding distinctly from the conidium outline. Secondary conidia ovoid or pear-shaped, smaller. Pseudocystidia conical, 70-120 μm long, 9-14 μm thick at the height of conidiogenous layer, tapering to about 6 μm at blunt tips. Rhizoids monohyphal about 10-15 μm wide, terminated with network of irregular branches or widened, disc-like reticulate holdfasts. Resting spores unknown.

Distribution and hosts. Great Britain and France, probably also other European countries, on chrysomelid beetles of the tribe *Galerucini*; identified species — *Lochmaea suturalis* Thomson and *Pyrrhalta luteola* (Müller). Hitherto not reported from Poland.

Remarks. The description has been prepared on the basis of rich material of infected beetles *Pyrrhalta luteola* obtained from Dr. F. Herard (European Parasite Laboratory, Behoust-Orgerus in

France). It is entirely comparable with the original description (B e n-Z e' e v 1987) based upon P e t c h' s material from *Lochmaea suturalis*, differing slightly only in measurements of some structures. The fungus has been originally reported by P e t c h (1944, 1948) from Great Britain under the name „*Entomophthora anglica*" P e t c h. The heterogeneity of materials labelled in the Kew Herbarium under this name was suggested by B a l a z y (1984) and partially recognized by B e n-Z e' e v (1986, 1987).

48. *Zoophthora vomitoriae* R o z s y p a l

Zoophthora subg. *Pandora vomitoriae* R o z s y p a l, Acta Mycol. 2: 23. 1966; — *Erynia vomitoriae* (R o z s y p a l) R e m a u d i è r e et H e n n e b e r t, Mycotaxon 11: 302. 1980; — *Erynia* subg. *Neopandora vomitoriae* (R o z s y p a l) R e m a u d i è r e et H e n n e b e r t ex B e n-Z e' e v et K e n n e t h, Mycotaxon 14: 462. 1982; *Furia vomitoriae* (R o z s y p a l) H u m b e r, Mycotaxon 34: 451. 1989.

Hyphal bodies as short segments of hyphae, elongated but of irregular shapes, often branched, about 25-70 (-150) x 20-35 µm. Hyphae 9-11.5 µm thick, sparingly branched. Conidiophores 11.5-13.5 µm thick, typically ramose; conidiogenous cells irregularly cylindric, 33-39 x 11.5-13 µm. Primary conidia ovoid to broadly claviform but of slightly converging sides towards the base (Fig. 28a), 28-36 (-44) x 12-18 µm, with papillae arcuate convex, 5.8-7.5 µm wide. Secondary conidia ovoid, smaller and smaller in consecutive series. Pseudocystidia numerous, rather long, 180-400 µm, of weakly converging sides from 15-18 to 8-10 µm of the thickness. Rhizoids monohyphal, ribbon-like, 12-25 (-35) µm wide, terminated with distinct, coarse disc-like expansions (Fig. 9c, d). Resting spores hyaline globose, 25-52 µm in diam., of the walls about 2.5 µm thick and smooth surface.

The fungus grows and sporulate well in cultures on artificial media containing egg yolk. Colonies attain 1-1.5 cm in diam. in 7 days. Primary conidia ovoid or ellipsoid of the measurements similar as on insects, except that papillae are very narrow, often almost wart-like 2.5-3.5 µm wide. Secondary conidia normal.

D i s t r i b u t i o n a n d h o s t s. Central and Eastern Europe (Bohemia, Poland, former USSR), on big flies of the families *Calliphoridae* (*Calliphora vomitoria* L., *C. erythrocephala* M e i g e n), *Syrphidae* and *Stratiomyidae*.

O c c u r r e n c e i n P o l a n d. Białowieża Forest, Świdnik near Lublin, Wielkopolski National Park, Poznań experimental frog rearing at the Research Center for Agricultural and Forest Environment (Pol. Acad. Sci.).

Subgenus Zoophthora

Zoophthora subg. *Zoophthora* B a t k o, Acta Mycol. 2: 16-18. 1966; — *Erynia* subg. *Zoophthora* B e n-Z e' e v et K e n n e t h, Mycotaxon 14: 466-469. 1982. — *Zoophthora* B a t k o

sensu Remaudière et Hennebert, Mycotaxon 11: 31. 1980 (as a generic name); — *Entomophthora* subg. *Lophorhiza* Giard, Bull. Sci. France Belgique 19: 303-304. 1888.

Mycelium filling the host's body cavity develops in a form of segmented and often branched hyphal bodies and filamentous, cenocytic, sparingly septate hyphae. Conidiophores richly digitately branched in their top part, the terminal conidiogenous branchlets usually clavate or cylindric, of the size close to the dimensions of primary conidia. The latter oblong ellipsoid to narrow cylindric with both ends obtuse or with distal end somewhat conical (Fig. 7x, y). Papillae of the same width or indistinctly narrower than the diameter of the conidia. Secondary conidia of the same type of ballospores, in subsequent series more and more ovoid, broadly fusiform, barrel-shaped or pear-shaped, of L:D ratio steadily diminished. Capilliconidia monokaryotic, regularly present, although in some species or strains hard to produce under laboratory conditions, of rather constant shapes for particular species. Resting spores globose, rerely subglobose, hyaline or coloured of smooth or rough epispore, forming mainly as azygospores although connexions of hyphal bodies suggesting conjugation have often been observed in intramatrical mycelium. Pseudocystidia regularly present, equally narrow, or conical, not or little thicker than conidiophores or hyphae. Rhizoids present, coalescent into pseudorhizomorphs and often intermixed with the single ones; their ends richly and densely branched form plane, reticulate holdfasts of uneven margins (Fig. 9b).

Pathogens of insects, causing often epizootics in natural populations. Particular species or strains seem to be closely connected with determined insect species and its development phase, appearing regularly in the same periods and localities, adapted to development cycles of their hosts. The only report on artificial infection of the mite *Tetranychus urticae* Koch by „*Entomophthora sphaerosperma*" in glasshouse (Egina & Tsinovskii 1972) seems to be poorly documented. Most of the strains develop well on artificial media enriched with egg yolk showing, however, decline of vitality with age, demonstrated by loss of sporulation, slower and slower growth of colonies and degeneration of mycelium. Some species develop also on common PDA and SA, much better with addition of yeast extract. The strains developing on PDA produce abundant and usually typical capillispores on this substrate.

Remarks. Although the recent systematical arrangements tend to elevate this subgenus to the generic rank (Remaudière & Hennebert 1980, Remaudière & Keller 1980, Humber 1989), the author consider it reasonable to maintain the genus *Zoophthora* sensu Batko (1964) as well defined and consistent taxonomical unit, with proposed by him infrageneric differentiation (Batko 1966), practically accepted recently by most contemporary investigators with some corrections (Ben-Ze'ev & Kenneth 1982).

Key to species

1. Primary conidia short ellipsoid or ovoid of L:D ratio less than 2 or of two types: cylindric elongate with rounded ends of L:D ratio about 3 and ovoid or short ellipsoid, distinctly thicker 2
1*. Primary conidia of one type, slender ellipsoid or cylindric of L:D ratio always more than 2 3

2. Primary conidia of one type, short ellipsoid 15-22 x 10-12 µm; on geometrid moths . . . . . *Z. geometralis*, p. 229
2*. Primary conidia of two types: ovoid or short ellipsoid 12.6-30.8 x 8,2-16,5 µm and long ellipsoid 17.1-33.3 x 5.9-12.9 µm; on the aphids *Myzus persicae* . . . . . *Z. anhuiensis*, p. 211

3. Average length of primary conidia does not exceed 20 µm and only single of them attain exceptionally 25 µm 4
3*. Average length of primary conidia about 20 µm or more and at least a considerable number of them exceeds 25 µm 14

4. Central, almost cylindric parts of capilliconidia relatively long, covering about half of total capillispore length, their basal and distal ends conical; L:D ratios of the primary conidia 2.7-2.8 µm, of capillispores 3.9-4.5; colonies floccose of vinaceous red mycelium; on adult brachycerous diptera of the family *Dryomyzidae* in late autumn . . . . *Z. autumnalis*, p. 218
4*. Capilliconidia with converging or sinuose sides in outline, without distinct and long central cylindric part or with that very short; cultures white, cream or waxy light brownish with age 5

5. Capilliconidia slender, usually 20-30 µm long of L:D ratio about 4-6, uniformly tapered towards tips 6
5*. Capilliconidia about 15-20 µm long of L:D ratio usually not exceeding 3 or close to 9

6. Capilliconidia — especially these of first series — distlinctly hyperbolic curved at about half of their height; on the ant *Myrmica laevinodis* (*Hymenoptera*) . . . . . *Z. falcata*, p. 225
6*. Capilliconidia slightly bent or only asymmetric, with the ventral side almost straight or indistinctly concave 7

7. On small staphylinid beetles (*Tachyporus* sp.); ventral line of capillispores almost straight or unremarkably uniformly concave in upper part . . . . . *Z. tachypori*, p. 248
7*. On adult *Diptera*; ventral line of capillispores straight or somewhat sinuose, with concavity in the upper part 8

8. Capilliconidia lenceolate with greatest diameter in their basal half; primary conidia 15-24 x 6-9 µm; resting spores hyaline *Z. lanceolata*, p. 235
8*. Capilliconidia fusiform, with the greatest diameter at about half of their height of the profile outline bow-shaped, almost bipolarly symmetric; primary conidia 17-22 x 5.5-6.2 µm; resting spores smoky with blackish-brown epispore . . . . . *Z. opomyzae*, p. 237

9. Capilliconidia — particulary on PDA — obtuse at distal ends or their side lines form conical, subacute tips, in profile somewhat asymmetric, not elongated into beaks, but sometimes with small terminal haptors . . . 10
9*. Bends of dorsal and ventral outlines of at least a considerable number of capilliconidia form subacute or acute beak-like conical elongations bent towards ventral side 12

10. Primary conidia short, of av. dimensions 15.5-16.5 x 5.5-6.2 µm, exceptionally longer; capilliconidia very rare; growth on media very slow and not typical, without sporulation; on foliophagous geometrid caterpillars . . . . . *Z. brevispora*, p. 221
10*. Length of primary conidia mostly between 17-19.5 µm; growth and sporulation on media containing egg yolk normal 11

11. Capilliconidia on insects fusiform not markedly asymmetric, of ventral side slightly convex and dorsal stronger arcuate, with conical distal ends, in capillispores obtained on PDA — rounded; on larvae of *Arge berberidis* (*Hymenoptera*) . . . . . *Z. arginis*, p. 217
11*. Capilliconidia in profile distinctly asymmetric with ventral side sinuose, often slightly concav in upper part and with obtusely conical ends, sometimes with rudimentary, irregular haptors; on small nematocerous flies . . . . . *Z. nematoceris*, p. 240

12. On adult psyllids; capilliconidia mostly amygdaliform with beak-like, rather thick, elongation marked by shallow concavity in upper part of ventral outline . . . . . *Z. psyllae*, p. 247
12*. On other insects; beak-like elongation less distinct and thicker, marked mostly by different bendings in central and upper parts of dorsal outline 13

13. On mirid bugs, occasionally on leafhoppers in the same habitats; beak-like elongations of capillispores on PDA long, obtuse . *Z. miridis*, p. 238
13*. On adult ichneumonids; capilliconidia on PDA with rather pointed but not prominent elongations . . . . . *Z. ichneumonis*, p. 231

14. Average length of primary conidia balances about or little over 20 µm, but some of them are shorter or exceed 25 µm 15

14*. Primary conidia distinctly longer, their average length usually about 25-40 µm, conidia shorter than 20 µm do not occur or sporadical 17

15. Central, almost cylindric parts of capilliconidia relatively long, both ends similarly short conical obtuse; on grasshoppers in deciduous forests . . . . . *Z. giardii*, p. 230

15*. Capilliconidia with arcuate or sinuose dorsal and ventral sides in outline, without distinct long, cylidrical central part 16

16. Dimensions of primary conidia rather constant, of confidence interval 20-20.6 x 6 µm, only single shorter than 20 µm or longer up to 25 µm; average L:D ratio 3.4; capilliconidia elongate, bent, very slightly attenuated towards obtuse ends; on brachycerous flies (probably of the group *Calyptrata*) . . . . . *Z. obtusa*, p. 241

16*. Confidence interval of the length of primary conidia ranging for particular strains in limits of about 5-10 µm, mainly from 19-25 x 5.5-6 µm, L:D ratio 3.6-4.5; capilliconidia with dorsal side strongly and the ventral one slightly convex, the former in upper part often mildly sinuose concave, forming short pointed or subacute beak, in cultures on PDA acute; on cabbage butterfly (*Pieris brassicae* L.) ceterpillars and pupae . . . . . *Z. radicans*, p. 207

17. Maximum length of primary conidia seldom exceeds 30 µm; their average dimensions closed in the range 21-30 x 6.5-10 µm for particular strains, of L:D ratio 2.8-3.5 18

17*. Primary conidia commonly longer then 30 µm, their average dimensions closed in the range 27-40 x 7.5-12 µm, of L:D ratio 2.5-4.5 for particular strains 27

18. Capilliconidia fusiform of acute or subacute ends 19

18*. Ends of capilliconidia obtuse or shortly rostrate with blunt apex . . . 20

19. Primary conidia 21-25 x 6.6-7.3 µm of L:D ratio 3.3-3.5; on earwigs (*Dermaptera*) . . . . . *Z. forficulae*, p. 226

19*. Primary conidia 25 x 10 µm of L:D ratio about 2.5; on aphids *Schizolachuns piniradiatae* . . . . . *Z. canadensis*, p. 222

20. L:D ratio of capilliconidia about 2, their ovoid basal part is narrowed into asymmetrical short beak owing to concave sinuosity in upper part of ventral outline; primary conidia 22.5-25.5 x 7.5 µm; on leaf-hoppers (*Auchenorrhyncha*) . . . . . *Z. petchii*, p. 243

20*. L:D ratio of capilliconidia 3-4 or more, their tips uniformly blunt, without terminal beak 21

21. Aphid pathogen; capilliconidia amygdaliform 24.5-29.5-5.5-10.3 µm; primary conidia 23.7-31.6 x 6.3-10.3 µm . . . . . *Z. orientalis*, p. 243

21*. On other insects 22

22. On adult tipulids (*Diptera*); capilliconidia narrow fusiform of L:D ratio about 6.5 . . . . . *Z. humberi*, p. 231

22*. On other insects 22

23. Mycelium or colony surface in arificial cultures green, with abundant conidiation; capilliphores 60-110 µm long, capillispores slender fusiform or banana-shaped; on elaterid beetles or heteropterous bugs 24

23*. Mycelium in atificial cultures white to cream or dirty yellowish, poorly developing with scarce or no conidiation; capillisphores at most 2-2.5 times longer than capillispores, the latter rather plump 25

24. Primary conidia mostly 25-35 x 9-10 µm, cylindric with broadly obtuse ends; on adult beetles of *Agriotes* sp. (*Coleoptera*: *Elateridae*) . . . . . *Z. anglica*, p. 209

24*. Primary conidia mostly 21-26 x 8-9 µm, subfusiform, with somewhat narrowed base and distal end; on *Notostria elongata* (*Heteroptera*: *Miridae*) . . . . . *Z. viridis*, p. 249

25. On larvae and pupae of *Phytonomus* spp. (*Coleoptera*: *Curculionidae*); primary conidia mostly 23-26 x 7 µm, of L:D ratio about 3.2-3.6 . . . . . *Z. phytonomi*, p. 245

25*. On *Lepidoptera* 26

26. On foliofagous geometrid caterpillars in spring; primary conidia 23-30 x 6,5-8.5 µm of L:D ratio 3.4-3.9; ventral side of capilliconidia convex, sometimes with hardly marked mild subapical concavity, but never crescent-shaped; capillary sporophores relatively thick, usually little longer than capillispores . . . . . *Z. bialoviezensis*, p. 219

26*. On small adult moths in summer; primary conidia 25-31 x 8.5-9.5 of L:D ratio 2.7-3.5; ventral side of crescent shaped capilliconidia regularly arcuate concave or almost straight; capillary sporophores thin, at least twice longer than capillispores . . . . . *Z. crassispora*, p. 223

27. Pathogens of aphids 28

27*. Pathogens of beetles 30

28. Primary conidia cylindrical, sometimes bent, with both ends obtusely rounded, 26-34 x 7.8; resting spores unknown . . . *Z. phalloides*, p. 244

28*. Primary conidia with conically tapered or pointed apical part, typically 28-35 µm long; resting spores globose, commonly produced 29

29. Primary conidia 7.5-9.5 µm thick of L:D ratio 3-4.5; capilliconidia with concave arcuate or sinuose, in upper part deeply concave, ventral outline, elongated into short subacute beak; resting spores hyaline 27-29 µm diam; . . . . . *Z. occidentalis*, p. 242

29*. Primary conidia 9-12 µm thick of L:D ratio 2.5-3.3; concavity of ventral side capilliconidium outline in profile only hardly marked, wart-like apex blunt; resting spores black-brown 36-41 µm in diam . *Z. aphidis*, p. 211

30. Primary conidia slender 40-41.2 x 7.5-9.1 µm, of L:D ratio about 4.5; capilliconidia and resting spores unknown; on a larva of cantharid beetle . . . . . *Z. larvivora*, p. 235

30*. Primary conidia 25-35 x 8.5-12 µm of L:D ratio about 3; capilliconidia elongate, slightly falciform bent, 33-39 x 8-9 µm; resting spores spherical brown 35-56 µm in diam.; on adult cantharid beetles . . . . . *Z. crassistunicata*, p. 224

49. *Zoophthora radicans* (Brefeld) Batko

Zoophthora radicans (Brefeld) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 324. 1964; *Empusa radicans* Brefeld, Bot. Ztg. 28: 186. 1870; — *Entomophthora radicans* Brefeld, Bot. Ztg. 35: 345. 1877. — *Erynia radicans* (Brefeld) Humber, Ben-Ze'ev et Kenneth in Humber et Ben-Ze'ev, Mycotaxon 13: 509.1981; — *Erynia* subg. *Zoophthora radicans* (Brefeld) Humber, Ben-Ze'ev et Kenneth ex Ben-Ze'ev et Kenneth Mycotaxon 14: 467. 1982.

Mycelium filling host's hemocel consists of hyphal segments of different length, from about 25-100 µm or more, 7-12 µm thick, oligokaryotic, often with one to three-four irregular branches or outgrowths. Superficial hyphae and conidiophores (4-) 6-8 (-10) µm thick, the latter richly digitately branched or repeatedly bifurcate in top part. Conidiogenous cells claviform or bottle-shaped, 19.5-27 x 7-11 µm. Primary conidia obtained from infected insects (17.5-) 19.5-22.5 (-27.5) x (4.7-) 5.5-6 (-6.5) µm of L:D ratio typically 3.5-4.5, whereas from cultures regularly shorter — 18.9-21.5 x 5.7-6.1 µm, of L:D ratio 3.2-3.5. Secondary ballospores of the first, second and third series practically indistinguishable from the primary conidia, subsequent series gradually shorter and thicker, sometimes pyriform or barrel-shaped. Typical capilliconidia of the ventral line weakly convex or almost straight, dorsal line strongly convex with a mild concavity below apex, forming often short subacute beak, in many strains indistinct. Capillispores produced on EY media not so typical, whereas on PDA very abundant and of rather constant shape (Fig. 35a-M). Capillary sporophores thin, moderately long, (19-)25-40 (-47) µm, and 0.4-0.6 µm thick at their ends. Resting spores light golden yellow, globose, (19.1-) 23.5-26 (-33) µm, of the walls 3-3,5 µm thick, with smooth epispore, containing semilunar layer of condensed protoplasm and a relatively large oil globule. Pseudocystidia numerous conical, 9-14 µm thick, stretching up to about 150 µm over the pseudohymenial layer of conidiogenous cells. Rhizoids mostly in pseudorhizomorphs, particularly abundant in thoracical part, occurring on the lar-

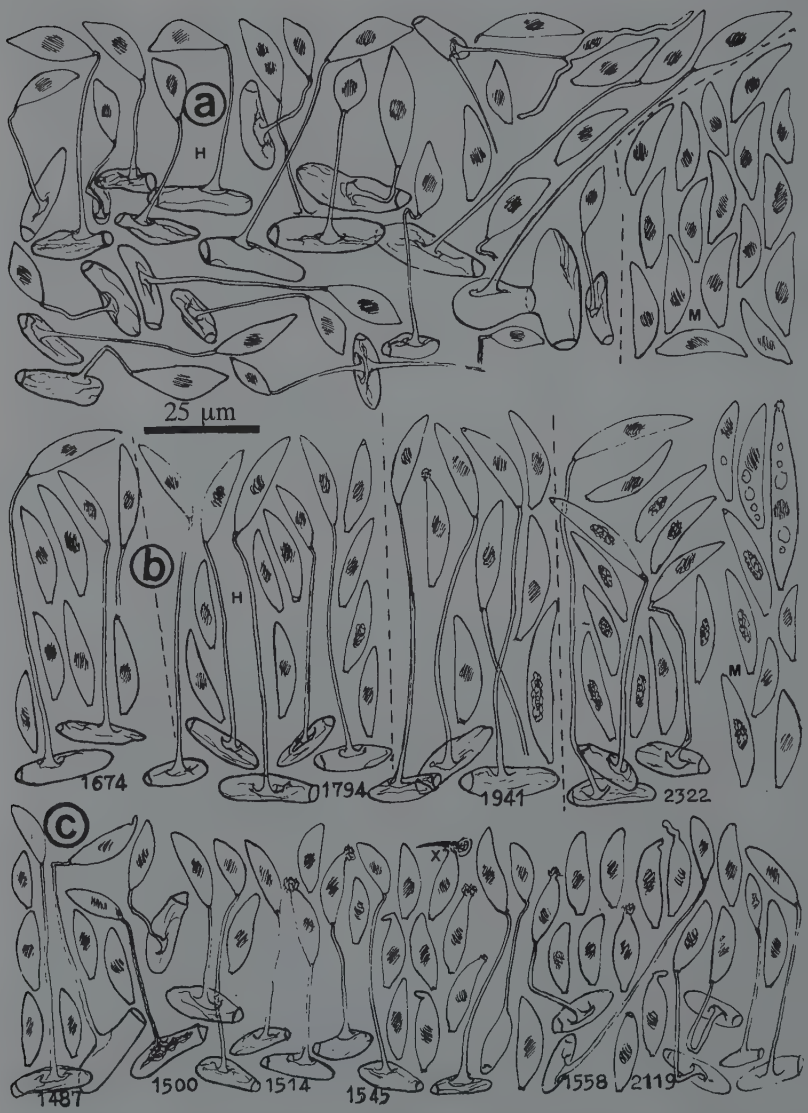


Fig. 35. Capilliconidia of *Zoophthora* spp. of the subgenus *Zoophthora*: a — *Z. radicans* (H — from host-insects, M — from culture on PDA; different colections from *Pieris brassicae* caterpillars); b — *Z. opomyzae* (H — from host-insects, M — from cultures on PDA (Wielkopolski National Park); c — *Z. nematoceris* from nematocerous flies, X — capillispore attached to host's seta (Białowieża).

vae covered with conidial sporulation and filled with resting spores. However, there were no rhizoids nor conidial sporulation on pupae filled with resting spores.

Growth and sporulation on artificial media good. Colonies on SDAEY media growing fairly rapidly, attaining 3-4 cm in diam. in 7 days, of the surface cream white to light brownish, after 4-5 days of waxy appearance caused by abundant conidial sporulation. Primary conidia of the same shape as on insects, on the average little shorter. Colonies on PDA small, attaining 1-1,5 cm in diam. in 7 days and stop at this phase of growth, surrounded with narrow halo of primary and secondary conidia and abundant capillispores of very uniform shape (Fig. 36). The cultures lost the ability to sporulate on SDAEY media after 10-18 months of continuous culturing but sporulated still on PDA.

Distribution and hosts. Europe, North America, on cabbage butterfly caterpillars (*Pieris brassicae* L.), rarely resting spores also in pupae.

Occurrence in Poland. Common all over the country, causing heavy epizootics in populations of *Pieris brassicae* and *P. rapae* caterpillars almost exclusively in late summer and early autumn (Pomerania — vicinity of Szczecin, Czarnków, Bydgoszcz, Kościerzyna, Wielkopolska — Poznań, Jarocin, Central Poland — Warszawa, Siedlce, Mogilno, Eastern Poland — Lublin, Puławy, Silesia — Wrocław).

Remarks. The fungi reported for 130 years under the name *Entomophthora sphaerosperma* Fres. 1856 from different host species were treated as synonymous with *Empusa radicans* Brefeld (1870). Thorough studies on their morphology, biology and particularly host specificity allowed to distinguish and describe a number of separate, closely allied species. Moreover, Batko (1964 c: 324) and Remaudière and Hennebert (1989: 303-304) concluded *Entomophthora sphaerosperma* Fres. to be an invalid name according to the rules of the Code International of Botanical Nomenclature, so the first validly applied name for it is *Empusa radicans* Brefeld (1870). In the author's opinion this species is a specialized pathogen infecting caterpillars of *Pieris* spp., and application of this name for pathogens of other insects is either incorrect or at least doubtful. All earlier materials, excluding those from *Pieris* spp. caterpillars, should be revised considering contemporary taxonomical criteria.

50. *Zoophthora anglica* (Petch) Humber

Zoophthora anglica (Petch) Humber, Mycotaxon 34: 453. 1989; — *Entomophthora anglica* Petch, Trans. Brit. Mycol. Soc. 27: 89. 1944 (p.p.); *Erynia anglica* (Petch) Ben-Ze'ev, Mycotaxon, 25: 1-10. 1986.

Entomophthora sphaerosperma Fres. ssp. *elateridiphaga* Turian Mitt. Schweiz. Ent. Gesellsch. 30: 96-99. 1957; — *Entomophthora elateridiphaga* Turian sensu Remaudière, Keller, Papierok et Latge, Entomophaga 21 (2): 170-171. 1976; — *Entomophthora elateridiphaga* Turian, Mitt. Schweiz. Ent. Gesellsch. 51: 395-398. 1978; — *Erynia elateridiphaga* (Turian) Humber, Ben-Ze'ev et Kenneth in Humber et Ben-Ze'ev, Mycotaxon 13: 509.1981; — *Zoophthora elateridiphaga* (Turian) Ben-Ze'ev et Kenneth, Entomophaga 25: 181. 1980; — *Erynia subg. Zoophthora elateridiphaga* (Turian) Ben-Ze'ev

et Kenneth ex Ben-Ze'ev et Kenneth Mycotaxon 14: 467. 1982. (?) *Entomophthora* subg. *Lophorrhiza carpentieri* Giard, Bull. Sci. France Belgique 19: 303-304. 1888.

Mycelium typically in form of elongate hyphal segments often branched or of roughly filamentous hyphae 8-12 µm thick, oligokaryotic. Conidiophores richly digitately branched; conidiogenous cells clavate or cylindric, 25-35 µm long and 9-12 µm thick. Primary conidia (21.5-) 23-30 (-34.3) x (8.2-) 9-10 (-11.7) µm [in one French strain collected in Acigné near Rennes 27.5-36.5 x 7.5-10 µm]. Secondary conidia similar, but in subsequent series with more and more smaller L:D ratios. Capilliconidia elongate, somewhat banana-shaped (Fig. 44b), about 20-32 x 5-7 µm, with conically attenuated, subacute, rarely blunt ends. Capillary tubes usually 70-110 x 1 µm thick at the base. Pseudocystidia not thicker than hyphae and conidiophores, hardly narrowing towards blunt tips, sticking out about 30-70 µm over conidiogenous layer. Rhizoids in 2-3 pseudorhizomorphs only in thoracical part or with single ones also growing between I and II abdominal sternites, forming relatively wide discs, expanded on substrate with irregular margins. Hosts attached mostly to grasses or herbaceous plant stems. Resting spores globose, hyaline or light yellow in mass (27-) 29-39 (-42) µm, surrounded with 3.5-4.5 µm thick wall of smooth epispore.

Growth and sporulation on different media containing egg yolk very good and rapid. Colonies at first cream white, floccose, becoming dark green on the surface with age and blackish brown in the reverse. Primary conidia in cultures little greater than on insects — in Polish strains (25.5-) 33-35 (-42) x (8-) 9.5-10 (-12) µm.

Distribution and hosts. Europe (France, Poland, Romania, Switzerland, USSR), on adult beetles of *Agriotes* spp. (*Elateridae*) mostly on strongly insolated slopes in areas of agrillaceous soils.

Occurrence in Poland. Wielkopolski National Park and Promno near Poznań, on *Agriotes sputator* L., *A. ustulatus* Schall. and *A. obscurus* L., very common in the second half of May; Białowieża Forest, on *A. lineatus* L., few specimens found occasionally (leg. E. Baraniak) in the first decade of June.

Remarks. Despite the presence of several other species of elaterid beetles in the investigated biotopes only *Agriotes* species were infected. In the past this fungus was most probably identified as „*Entomophthora sphaerosperma*" (Durnovo 1935). Host species and characteristic fasciculate rhizoids of the material described by Giard (1888: 303-304) under the name „*Entomophthora* subg. *Lophorhiza carpentieri*" indicate that this fungus might represent the same species. Keller (1982) identified a fungus infecting the mirid bug *Notostira elongata* Geoffr. as *Zoophthora elateridiphaga* (Turian) Ben-Ze'ev et Kenneth and renamed it later as *Z. viridis* Keller (1991). However, Keller (1991) does not accept Ben-Ze'ev (1986) conclusions concerning synonymy of *Entomophthora anglica* and *Z. elateridiphaga*, which are rather convincing and based on good documentation. He also expressed recently (Keller 1991: 100) the opinion that the fungus identified by Turian (1957) as *Entomophthora carpentieri* Giard seems to be rather the resting spore stage of *Zoophthora elateridiphaga*, which is in agreement with the author's conclusion (see p. 236–237).

(51). *Zoophthora anhuiensis* (Li) Humber

Zoophthora anhuiensis (Li) Humber, Mycotaxon 34: 453. 1989; — *Erynia anhuiensis* Li, Acta Mycol. Sin. 5 (1): 1-6. 1986.

Hyphal bodies undescribed. Conidiophores repeatedly bifurcate in upper part. Primary conidia long ellipsoid, 17.1-33.3 x 5.9-12.9 µm (av. 24.7 x 8.3 µm) or ovoid 12.6-30 x 8-16.5 µm (av. 22.7 x 11.6 µm). Secondary ballospores ovoid, generally smaller. Capilliconidia unknown. Pseudocystidia conical, only with the base disticntly wider than conidiophores, 14-28 µm thick. Rhizoids single or in bundles with differentiated, irregular holdfasts. Resting spores hyaline, smooth, globose, 22-32 µm in diam. (av. 26.6 µm), reported as exogenously produced.

Distribution and host. Described from the China People's Republic, causing epizootics in the green peach aphid (*Myzus persicae* Sulz.) populations.

Remarks. This fungus briefly described in the English summary seems to be a transitional form between the subgenera *Zoophthora* and *Furia* as regards the primary conidia and rhizoids, as well as between *Zoophthora* and *Erynia* as regards pseudocystidia. Moreover, the formation of resting spores reported as only in external mycelium seems to be rather unusual. Humber (1989) listed it among the species of the genus *Zoophthora* in his sense, but this affiliation should not be treated as definite at least until the possibility of capillispore formation and typical pseudorhizomorph-like character of rhizoids are confirmed.

52. *Zoophthora aphidis* (Hoffmann in Fres.) Remaudière et Hennebert

Zoophthora aphidis (Hoffmann in Fres.) Remaudière et Hennebert, Mycotaxon 11: 285-294. 1980 [nec *Zoophthora aphidis* (Hoffmann in Fres.) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 323-324. 1964]; — *Entomophthora aphidis* Hoffmann in Fres., Abhandl. Sénckenberg. Naturforsch. Gesellsch. 2:208. 1858; — *Erynia aphidis* (Hoffmann in Fres.) Humber et Ben-Ze'ev, Mycotaxon 13: 509. 1981; — *Erynia* subg. *Zoophthora aphidis* (Hoffmann in Fres.) Humber et Ben-Ze'ev ex Ben-Ze'ev et Kenneth, Mycotaxon 14. 467. 1982; — *Tarichium aphidis* (Hoffmann in Fres.) Cohn, Beitr. Biol. Pflanz. 1: 84. 1870.

Intramatrical mycelium in form of hyphal segments 60-150 µm long and 6-10 (-13) µm thick, often irregularly branched. Conidiophores of the same thickness, richly digitately branched in top part. Primary conidia oblong cylindric with the distal end usually elongated into conical projection, (21-) 24-35 (-38) x (8-)9-12 (-16) µm (av. for particular specimens ranging between 27.5-32 x 9.3-12 µm), of L:D ratios (2.1-) 2.5-3.3 (-3.9). Secondary ballospores similar to the primary but usually shorter. Capilliconidia short and rather plump (Fig. 36a), with the dorsal side (seen in profile) semicircular or so, and the ventral side almost straight or slightly convex, sometimes with short wart-like apical beak; seen „en face"

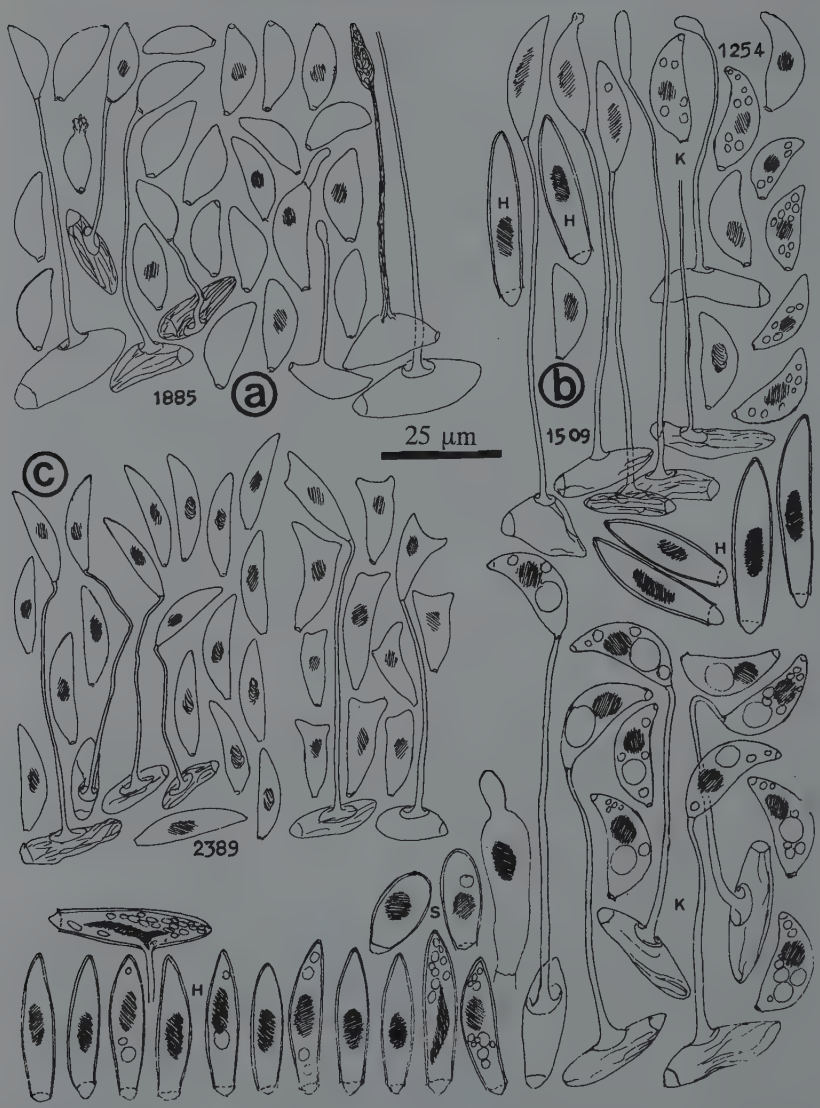


Fig. 36. *Zoophthora* subg. *Zoophthora* spp.: a — *Z. aphidis*, capilliconidia from host-insect (WRSL Herbarium); b — *Z. occidentalis*, H — primary conidia, K — capillispores, S — secondary conidia, from hostinsects; c — *Z. tachypori* — capilliconidia from host-insect.

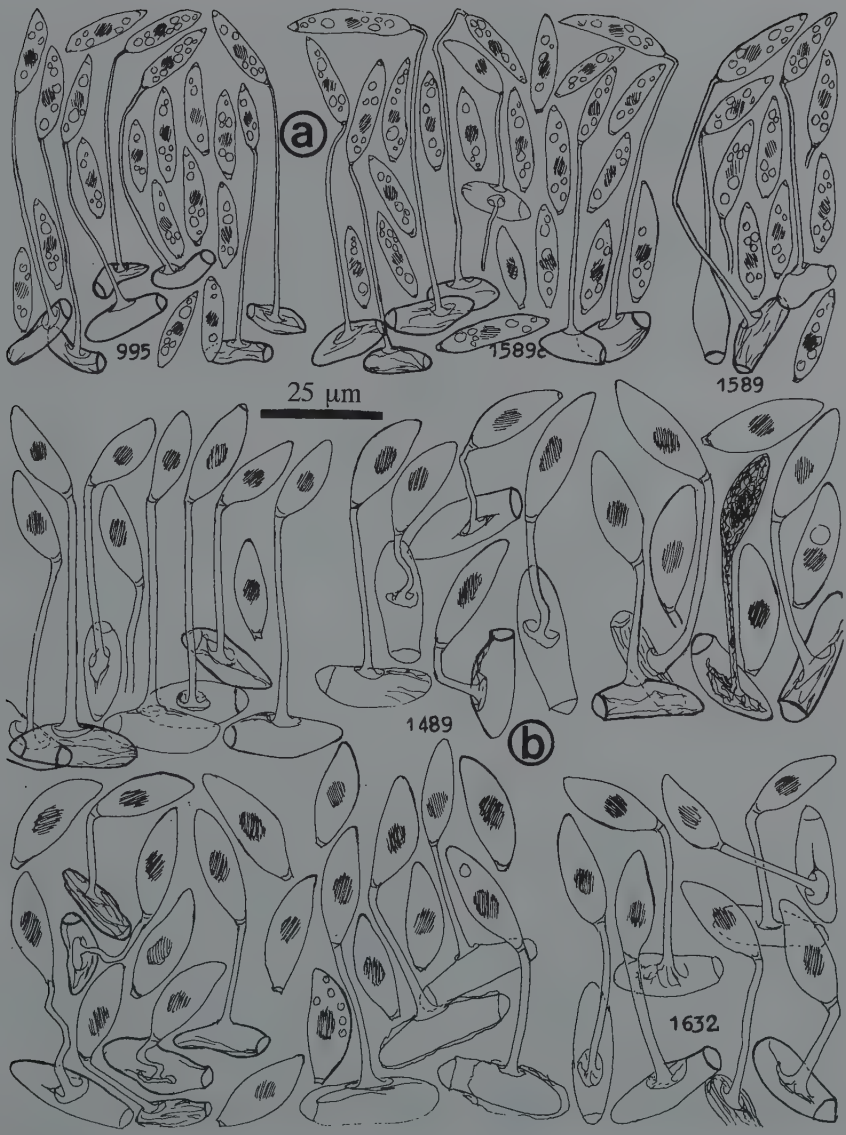


Fig. 37. Capilliconidia of *Zoophthora* spp. subg. *Zoophthora* from host-insects: a — *Z. autumnalis* (from dryomyzid flies: 995 — Holy Cross Mts. National Park, 1589 — Białowieża National Park); b — *Z. bialoviezensis* — from geometrid caterpillars (Białowieża).

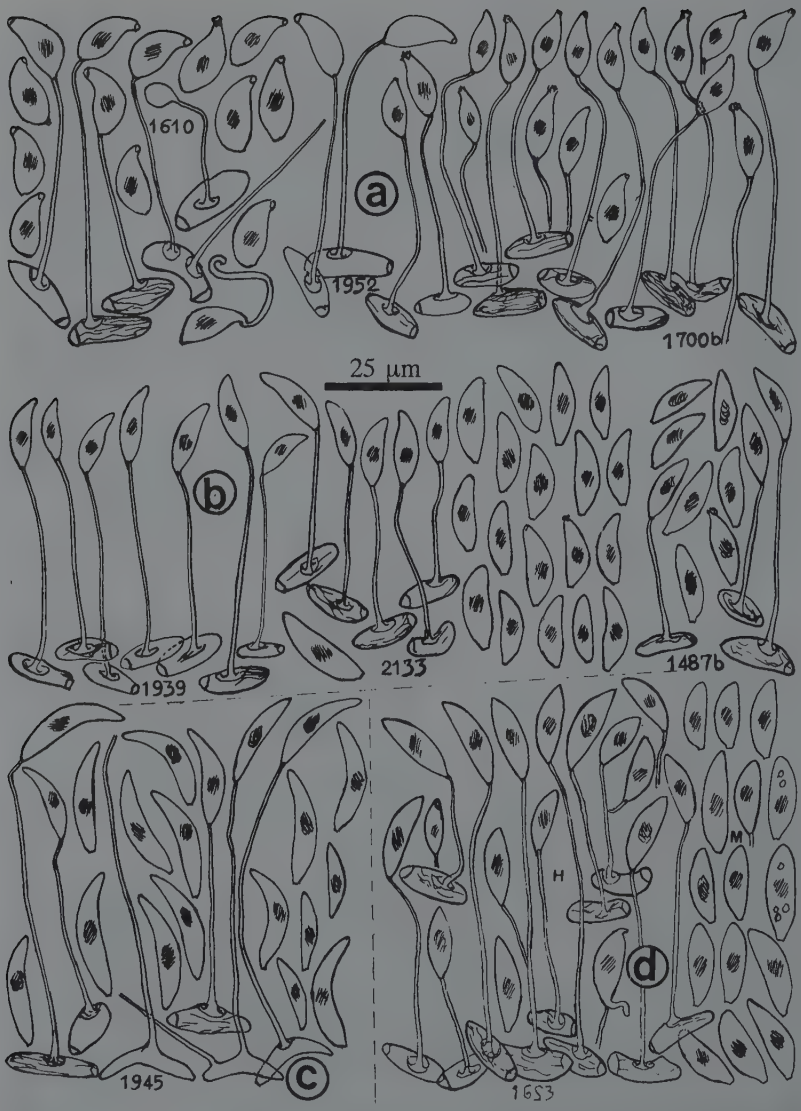


Fig. 38. Capilliconidia od *Zoophthora* sp. of the subgenus *Zoophthora*: a — *Z. petchii* from host-insects (different localities); b — *Z. psyllae*, from host-insects (different collections); c — *Z. falcata* from culture on PDA; d — *Z. arginis*, H — from host-insects, M — from cultures on PDA (Lublin).

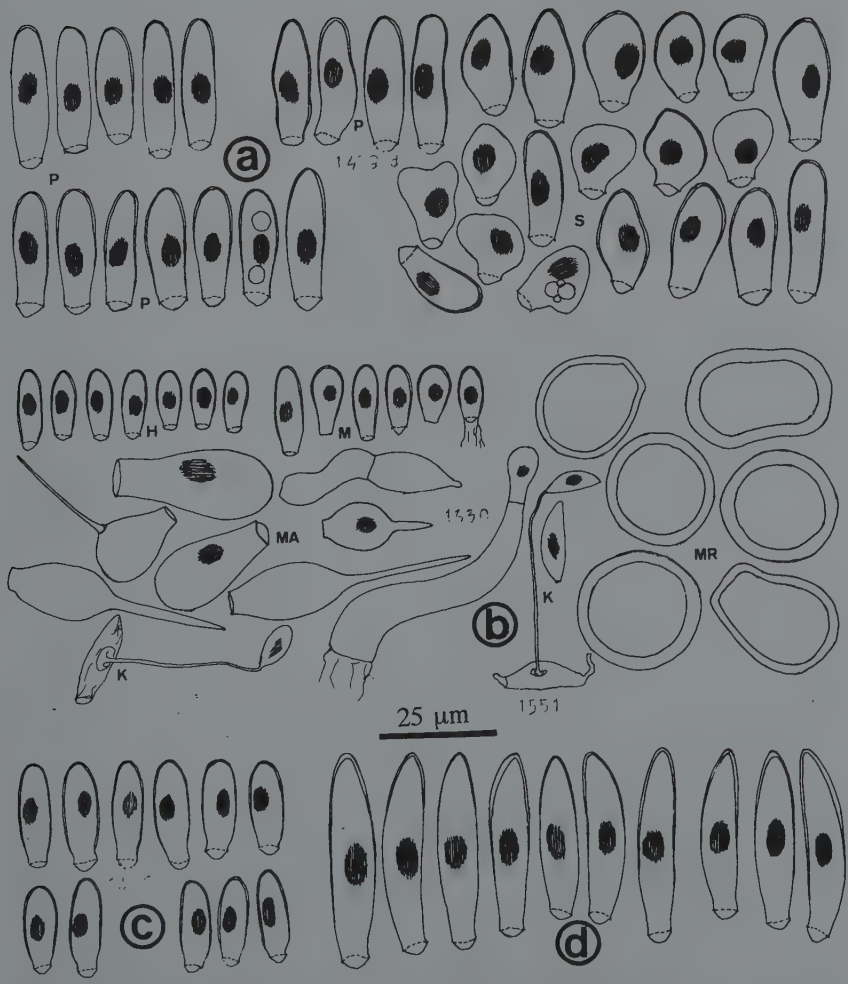


Fig. 39. *Zoophthora* subg. *Zoophthora* spp.: a — *Z. bialoviezensis* (P — primary conidia, S — secondary conidia; from foliophagous geometrid caterpillars — Białowieża Forest); b — *Z. brevispora* (H — primary conidia from host-insects, M — conidia from a fresh isolate on BPEYA, MA — atypical conidia produced after several months of culturing, MR — resting spores from a fresh culture, K — capillispores, from foliophagous geometrid caterpillars — Białowieża National Park); c — *Z. forficulae* from *Chelidurella acanthopygia* (Wielkopolski National Park); d — *Z. larvivora* from a larvae of cantharid beetle larva (Wielkopolski National Park).

— broadly fusiform (15-)18-28 (-30) x (8-) 9-13 (-16) µm, of L:D ratios (1.4-) 1.7-2.1 (-2.5). Rhizoids in pseudorhizomorphs, short, ended with irregular discs. Pseudocystidia not thicker than conidiophores relatively long. Resting spores spherical, (31-) 35-41 (-53) µm, surrounded by the two-layered wall 4-6 (-6.5) µm thick, of brown epispore with irregularly rough surface; no evident cases of conjugation have been observed. Growth on SDAEY media relatively rapid. Colonies at first white with cream shadow with age. Primary conidia somewhat greater than these produced on insects; capilliconidia not different; resting spores not produced.

Distribution and hosts. Western and Central Europe, on aphids of the genus *Anoecia* spp. infesting leaves of *Cornus* spp., mostly in autumn.

Occurrence in Poland. Reported by Wróblewski and Siemaszko (1933) from Puławy; this material is in KRAM Herbarium and contains elements of the fungus morphology, which does not differ from Rabenhorst's material in WRSL (see ramarks below). Remaudière and Hennebert (1980: 272-273) have quoted an information on a sample of this fungus in *Anoecia* sp. on leaves of *Cornus sanguinea* L. from Poland, deposited in the Royal Botanical Garden in Edinbourgh collection (leg. W. Siemaszko). The attempts to find this fungus in numerous populations of *Anoecia* species in the Wielkopolski National Park, Lublin-vicinity, Turew near Leszno, Białowieża National Park as well as in surrounding of Craiova in Southern Romania, Chambery in Eastern France and Laufen Germany, have so far been usuccessful.

Remarks. In the sample from the WRSL collection with the label identical as that quoted by Remaudière and Hennebert (1980: 271), besides all structures redescribed by these authors, also capilliconidia have been found on wings of several alate aphid specimens. Their shapes and sizes correspond in all aspect with Remaudière and Hennebert's (1980) and Keller's (1991) characteristics, confirming additionally the correctness of this species separation. The names *Entomophthora aphidis* Hoffmann in Fres. and deriving from it *Zoophthora aphidis* (Hoffm. in Fres.) Batko were till 1980 incorrectly applied to another, undescribed fungus, known at present under the name *Zoophthora* subg. *Naopandora neoaphidis* (Remaudière et Hennebert) Bałazy. Moreover, the first of the cited above names was also applied for other aphid pathogens, *Zoophthora* subg. *Zoophthora canadensis* (MacLeod, Tyrrell et Soper) Remaudière and Hennebert, as a result of misidentification, and *Z.* subg. *Neopandora nouryi* (Remaudière et Hennebert) Bałazy, which was not distinguished from *Z. neoaphidis*. The problem of the status of this species has been solved by Remaudière and Hennebert (1980). However, there are two nomenclatural inconsistencies in this paper. While typifying his subgenus *Pandora* by the species *Entomophthora aphidis* Hoffmann in Fres. Batko (1964) was unaware that this name had been misapplied for an as yet undescribed fungus. Since the later named *Erynia neoaphidis* Remaudière et Hennebert (1980: 307-312) represents obviously all features of the subgenus *Pandora* Batko, the latter cannot be treated as synonymous with the genus *Zoophthora* (Batko) sensu Remaudière et Hennebert (1980: 301). For the same reasons the combination *Zoophthora aphidis* (Hoffman in Fres.) in correct sense should not be ascribed to Batko, as Remaudière and Hennebert (1980: 290) and Humber (1989: 453) have done. Erroneous Batko's typifying of the subgenus *Pandora* was corrected by Ben-Ze'ev & Kenneth (1982: 460-461) who renamed it *Neopandora* and typified by *Erynia neoaphidis* Remaudière et Hennebert.

53. *Zoophthora arginis* Bałazy n. sp.

Diagnosis. *Mycelium hospitis corpus implet, e hypharum segmentis ramosis, varia longitudine, crassitudine 5-10 μm, cum inflationibus usque ad 12 μm, constans. Conidiophora 7-10 μm crassa, in apice magnopere digitosa. Cellulae conidiogenae circa 20 μm longae, 7-8 μm crassae. Conidia primaria cylindrata, utrimque obtusa, in hospitis corpore dimensionibus (15-) 16.5-20.5 (-24) x 5.5-6.0 (-6.5) μm, L:D* proportione 2.9-3.6, in cultura artificiali breviora, dimensionibus (12-) 14-15 (-18) x (5-) 5.5-6.2 (-8.5) μm. Conidia secundaria breviora. Capilliconidia in dimensiones 16-19.5 x 5.7-6.6 μm, L:D proportione non maior quam 3, cum lineamentibus ventralibus fere rectis at dorsalibus regulariter arcuatis. Pseudocystidia 110-180 μm longa, in crassitudinem ad basim 7,5-10 μm, deinde leniter attenuata ad 5-6.5 μm; cum apicibus obtusis vel paulum inflatis. Nonnulla pseudocystidia ad basim magnopere inflata — usque ad 20 μm. Rhizoidea monohyphalia et fasciculata. Sporae perdurantes globosae, diametro (19-) 20-24 (-25.5) μm, cum pariete laevi; 2.5-3.2 μm crasso. In larvis Hymenopterorum Arge beberidis parasitans. In cultura artificiali cito augetur et largiter sporas format. Mycelii color in superficie,sordid oalbus, deinde claro-brunneus.*

Holotypus. *Specimen numero 1693 c in collectione* ZBS PAN *designatum, in horto Universitatis M. Curie-Sklodowska,* Lublin *(Polonia), die 7 mensis Iulii anno 1985 collectum (*leg. Z. Machowicz-Stefaniak*), in praeparatione microscopica et in solutione fixativa conservatum. *Abbreviatione L:D utimur, quae in lingua Anglorum proportionem longitudinis ad crassitudinem significat.*

Mycelium filling host's body consists of hyphal segments 4.5-10 μm thick with numerous puffs up to 12 μm and usually with irregular, short branches. Conidiophores 7-10 μm thick, richly branched at their tips. Terminal conidiogenous branches clavate, about 20 x 7 μm, form velvety layer just over host's cuticle. Primary conidia long ellipsoid or cylindric, (15-) 16.5-20.5 (-24.2) x (5.4-) 5.5-6 -(6.4) μm, of L:D ratio in rather narrow range 2.9-3.6. Secondary ballospores similar but shorter and of smaller L:D ratio. Capilliconidia forming hardly and in small numbers in material from insects in damp chambers, rather short, 16-19.5 x 5.5-6.5 μm, seen in profile with ventral outline weakly convex or indistinctly sinuose-concave in upper part, the dorsal one regularly bow-shaped with typical sub-basal concavity; distal ends usually conically subacute, rarely obtuse — especially from cultures on PDA (Fig. 38d-H). Capillary sporophores thin, about 30 μm long. Rhizoids typically in pseudorhizomorphs and monohyphal. Pseudocystidia stretching 110-180 μm over the conidiogenous layer, weakly attenuating toward apex from 7.5-10.2 to 4.7-6.5 μm, ends obtuse, often slightly inflated. Some pseudocystidia with distinct bulbous extensions up to about 20 μm in diam. at the base. Resting spores light golden yellow, smooth, globose, (18,7-) 20-24 (-25.5) μm in diam. of

walls 2.5-3.2 μm thick, forming laterally on hyphae or their branches as azygospores, thin-walled and 30-41 μm in diam. when young.

The fungus develops well and sporulate in cultures on media enriched with egg yolk, forming fairly rapidly growing colonies of cream to light brown surface. Primary conidia are smaller and thicker but typical, (12-) 14-15 (-18) x (5-) 5.8-6.2 (-8.5) μm,, of L:D ratio about 2.5. Capilliconidia very uniform and abundantly produced on PDA (Fig. 3d-M).

Distribution and host. Poland, Lublin, University Park, on larvae of *Arge berberidis* Schrank (*Hymenoptera: Argidae*), causing regularly epizootics in the beginning of July and in September, observed every year since 1973. In September 1992 this species was found in Southern Germany near Laufen (Bavaria) on the same host.

Remark. This species is very close to *Z. radicans* and was at first reported under this name (Bałazy 1982: 227). Apart from remote host insects there are differences in morphology, namely in the shape of capilliconidia both from insects and from PDA, and in the size of the primary conidia which are on the average shorter and of smaller L:D ratio.

Etymology: *Arge* — generic name of the host species.

54. *Zoophthora autumnalis* Bałazy, n. sp.

Diagnosis. *Hyphae* 3-10 μm *crassae, irregulariter nodosae usque ad 13.5* μm. *Conidiophora 5.5-7.5* μm *crassa, in apice digitose ramosa; cellulae conidiogenae dimensionibus 17-20 x 6-6.7* μm. *Conidia primaria breviter cylindrata vel ellipsoidalia, in dimensiones (15.5-) 17.5-18.5 (-21) x (5.7-) 6.5-6.7 (8.6)* μm, *L:D proportione minore quam 3. Conidia secundaria minora, ellipsoidalia vel ovata. Capilliconidia fusiformia, recta vel leniter inflexa, L:D proportione ca 4, utroque latere convenientia, dimensionibus (16-) 18-21.5 (24.5) x (1-) 1.4-5.5 (-6)* μm, *utrimque acuta. Pseudocystidia indistincta, brevia. Rhizoidea in pseudorhizomorpha typica contexta, raro cum monohyphalibus intermixta. Sporae perdurantes ignotae. In imaginibus Dipterorum familiae Dryomyzidae parasitans. Pigmentum floccosum mycelii in cultura artificiali primum album, deinde in roseum, denique in vineo-rubrum transcolorans etiam substrato infusum. Sporulatio typica.*

Holotypus. *Specimen numero 1589 designatum, in silva virginea Bialoviezensi, die 12 mensis Octobris anno 1983 collectum* (leg. S. Bałazy), *in praeparatione microscopica et in cultura exsiccata in collectione* ZBS PAN *depositum.*

Mycelium consisting of almost parallelepipedous hyphae 3-10 μm thick, with irregularly distributed nodular widenings up to 13.5 μm in diam. Conidiophores 5.5-7.5 μm thick, digitately branched; the terminal conidiogenous cells 17-22 x 6-6.7 μm, usually the thickest in distal parts. Primary conidia short cylindric with

rounded ends, of very constant shape and sizes, (15.5-) 17.5-18.5 (-21.5) x (5.5-) 6.5-7 (-8.6) μm and of L:D ratios 2.7-2.9. Secondary conidia gradually shorter, in subsequent series conspicuously inflated in the central part. Capilliconidia (Fig. 37a) in outline fusiform, with relatively long central cylindric part, of both ends almost bipolarly symmetric short conical or with the distal one longer, usually acute. Their measurements range between (16-) 17.8-21.5 (-24.7) x (4-) 4.5-5.5 (-6) μm. Capillary sporophores thin, moderately long, 30-55 x 0.8-1.2 μm, attenuating to 0.4-0.6 μm at tips. Rhizoids typical. Pseudocystidia not distinguishing among the bunches of conidiogenous cells.

The fungus develops and sporulates well in artificial cultures on media containing egg yolk. On peptonized broth with egg yolk (PBEY) colonies grew rather slowly attaining in two weeks 10-16 mm in diam. Their surface was of floccose appearance, at first white, becoming pink and subsequently dull vinaceous red, with red colour also difunding into substrate. Conidial sporulation begins with third week and expands zonally during about a month onto all the surface of substrate (3 colonies on 10 cm diam. Petri dishes). Micromorphology of the mycelium and sporulation elements in cultures does not differ from those on insects.

Distribution and host. On dryomyzid flies affixed to underside of leaves in mixed forest undergrowth, collected on 3 October 1975 in the Holy Cross Mts. National Park (Central Poland) near Święta Katarzyna village and on 12 October 1983 in the Białowieża National Park.

Remarks. This species is easy to distinguish from other fungi infecting flies by different shape of capillispores and red colour of the mycelium in cultures. With regard to shape and size of the primary conidia the closet species seems to be *Z. lanceolata* — differing, however, apart from above indicated features, also by much quicker growth rate of the colonies in cultures.

Etymology: *autumnus* (Lat.) — autumn, relation to the period of appearence in Poland.

55. *Zoophthora bialoviezensis* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia dimensionibus 15-36 x 11-22 μm, irregulariter ovata vel piriformia, e quibus hyphae paulum ramosae, 7-12 μm crassae excrescunt. Conidiophora 7.5-10 μm crassa, in parte subapicali fortiter ramosa. Cellulae conidiogenae clavatae, dimensionibus 25-30 x 7-9.5 μm. Conidia primaria cylindrata, utrimque obtusa, in dimensiones (20-) 22-32 (-38) x (6-) 7-8 (-8.5) μm. Series primae conidiorum secundariorum primariis similes, series sequentes, ovatae, piriformes vel etiam in lineamentis irregulariter multiangulae. Capilliconidia obtusa, amygdaliformia, cum linea ventrali in media parte convexa, in parte subapicali leniter concava; linea dorsalis fere regulariter semiorbiculata. Capilliphora (18-) 22-27 (-44) μm longa, crassitudine ad basim ca 2 μm, in apice ca 1 μm. Pseudocystidia 70-150 μm longa, ad basim 9-13 μm crassa, in apice pau-*

lum attenuata ad 6-9 µm. Rhizoidea typica, fasciculata. Sporae perdurantes ignotae. In mediis artificialibus luteum continentibus fungus male crescit et sporulas typicas non format. Mycelium post circa unum mensem moritur. Mycelium in medio artificiali „PDA" non crescit. In larvis Lepidopterorum familiae Geometridae parasitans.

Holotypus. *Specimen numero 1489 m designatum, in silva mixta Bialoviezensi (Polonia), die 4 mensis Iunii anno 1982 collectum, in collectione* ZBS PAN *depositum.*

Hyphal bodies irregularly ovoid or pyriform 15-36 x 11-22 µm giving rise to regular, scarcely branched hyphae 7-12 µm thick. Conidiophores 7.5-10 µm thick, richly digitately branched in their top parts; conidiogenous cells clavate or bottle-shaped, 25-30 x 7-9.5 µm, arranged into regular, dense, pseudohymenial layer about 70 µm over the surface of host's cuticle. Primary conidia cylindric, of both ends obtuse (Fig. 39a-P); their measurements range between (20-) 22-32 (-38) x (6-) 6.8-7.8 (-8.6) µm, (av. for particular strains 24-30 x 6.5-8.5 µm). Secondary conidia of the first and second series similar, in further series more and more ovoid, pyriform or even irregularly multiangular in outlines (Fig. 39a-S). Capilliconidia obtuse amygdaliform of distinctly blunt distal end, with ventral outline sinuose convex in central part and hardly concave beneath the tip, the dorsal side uniformly convex stronger than the ventral one (Fig. 37b). Capillary sporophores (18-)-22-27(-44) long, about 2 µm thick at bases and 0.9-1.3 µm at tips. Peudocystidia relatively stout, 10-12.5 µm thick at the base, weakly narrowing to obtuse tips 6-9.5 µm thick, sticking out about 70-150 µm over the pseudonymenial layer. Rhizoids typical, more numerous in thoracical part of host's body. Resting spores undescribed.

Particular strains of this fungus developed poorly on artificial media containing egg yolk and do not develop at all on PDA. The mycelium grew only in superficial layer of the medium forming cobwebby, under stereoscope delicately setose network of hyphae (2.5-)3-8 (-16) µm thick, with numerous long segments, devoid of protoplasm. In some young (about 1 week old) colonies single conidia were formed on ends of unbranched hyphae, but their papillae were never normally convex, nor they were forcibly discharged. In old colonies after 3-4 weeks only single, irregular round ovoid or pear-shaped cells sustained alive. The cultures lost their vitality after 2-3 months, despite different enriching of media.

Distribution and hosts. On foliofagous geometrid caterpillars (*Lepidoptera* — identified species: *Hibernia defoliaria* Cl., and *Cheimatobia brumata* L.) attached to undersides of laves in the undergrowth of hardwood forest of Białowieża, collected on 25 May 1975 and many times later (1981, 1982, 1983, 1988, always in the third decade of May and first days of June). The specimem of a geometrid caterpillar overgrown by sporulating mycelium, designated with number 1489 m in collection is indicated as the holotype.

R e m a r k s. The features of this species differentiate it from all described until now. After the morphology the closest seems to be *Z. phytonomi* (A r t h u r) B a t k o, however, deside differences in biology of host insects and habitats, also the size of the primary conidia differs significantly especially in length and L:D ratio.

The fungus causes regularly periodical epizootics in populations of geometrid caterpillars feeding on deciduous undergrowth leaves in all stands of the Białowieża Forest area, controlling their populations during gradation periods.

Etymology: Białowieża — a big village in Eastern Poland surrounded by the famous primeval forest, in which the described species abundantly occur.

56. *Zoophthora brevispora* B a ł a z y, n. sp.

D i a g n o s i s. *Corpora hyphalia ovoidea, irregulariter ellipsoidalia vel oblonga, dimensionibus 19-110 x 9-17* µm, *saepe cum appendicibus 2-4* µm *crassis. Hyphae intra hospitem 5-9* µm, *ad hospitem 4.5-6* µm *crassae, post hospitis mortem crescunt. Conidiophora crassitudine 4.5-8* µm, *typice ramosa; ramulae conidiogenae breviter claviformes, dimensionibus 15-20 x 5-6.5* µm. *Conidia primaria ellipsoidalia vel breviter cylindrata, in dimensiones (13.5-) 15.5-17.5 (-21) x (5-) 5.5-6 (-7.2)* µm, *L:D proportione minore quam 3. Conidia secundaria minora. Capilliconidia pauca, oblongo-ovoidea, in apice obtusa, in tenuibus capilliphoris crescentia. Pseudocystidia 70-130* µm *longa, 6.5-8.5* µm *crassa, nonnumquam cum appendicibus apicalibus circa 10* µm *longis et 4-4.5* µm *crassis. Rhizoidea typica, in pseudorhizomorpha contexta. Sporae perdurantes maturae — ignotae, in uno hospitis specimine immaturae azygosporae, diametro 22-32.5* µm, *globosae, cum tenuibus membranis inventae sunt. In larvis Lepidopterorum familiae Geometridae ex arborum frondosarum foliis. In medio artificiali* „BPEYA" *conidia singularia, atypica, dimensionibus (13-) 15-17 (-20) x 9.5-10.5* µm, *griseoalbas colonias tenues, dilutas, et setosas formant. Mycelium in* PDA *non crescit.*

H o l o t y p u s. *Specimen numero 1550 in collectione* ZBS PAN *designatum, in silva frondosa virginea Bialoviezensi die 21 mensis Maii anno 1983 collectum, in praeparatione microscopica et ad insectum exsiccatum depositum.*

Mycelium inside host's body in form of ovoid irregularly ellipsoid or oblong hyphal bodies 19-110 x 9-17 µm, often with thin appendicular outhrowths 2-4 µm in diam. and segmented hyphae of uneven thickness, 5-9 µm. The hyphae on insect body 4.5-6.5 µm thick. Conidiophores 4.5-7.8 µm thick, digitately branched in terminal part; sporogenous cells short-clavate 15-20 x 5-6.5 µm. Primary conidia broadly ellipsoid or short, cylindric with uniformly rounded ends, (13.5-) 15.5-17.5 (-21) x (5-) 5.4-6.1 (-7.2) µm, of L:D ratio ranging between 2.8-3. Secondary ballospores similar, smaller (Fig. 39b-H). Capilliconidia few, very hardly formed,

long ovoid with rounded distal end, a little asymmetric, born on thin tubes (Fig. 39b-K). Pseudocystidia almost evenly narrow, (5-) 6.5-8.5 µm thick, hardly inflated at tips or elongated into thin outgrowths about 10 x 4-4.5 µm, stick out 70-130 µm over the conidiogenous layer. Rhizoids typical, numerous in thoracical part of the host. Unripe azygospores globose, thin walled, 22-32.5 µm in diam., found in one specimen.

The fungus grew on peptonized BPEYA media forming thin, round floccose-setose, grey-white colonies of the diam. about 3 cm in two weeks, developing only in superficial layer of the medium. Typical hyphal mycelium with setose, 5-11 µm thick, aerial hyphae, developed only during few first days, transforming with age into irregularly vesicular hyphal bodies of very differentiated measurements. Single, not typical conidia were formed in 2-3 week old cultures, as elongate ellipsoid or clavate terminal cells of unbranched hyphae, separated by truncate papillae, but not thrown away. Their dimensions were (13.5-) 15-17 (-20) x 9.5-10.5 µm. There grew often long, needle-like outgrowths from the center of their top parts (Fig. 39b-MA). Resting spores hyaline, smooth, globose 21-26 µm in diam., and ovoid to ellipsoid 22-31 x 19-25 µm, with walls 2,5-3 µm thick (Fig. 39b-MR), were found in a fresh culture of one strain.

Distribution and hosts. On foliophagous geometrid caterpillars attached to leaf undersides of deciduous trees in the undergrowth; the Białowieża National Park, found on 4 June 1982 and 21-22 May 1983, together with *Z. bialoviezensis*.

Remarks. This fungus differs from *Z. radicans*, *Z. bialoviezensis* and other investigated species by the size and L:D proportions of the primary conidia and features of the mycelium in artificial cultures. In the WRSL Herbarium material there was found one dry specimen of a geometrid caterpillar overgrown and mummified by the fungus of identical characteristiecs both of conidia and mycelium. It has been labelled „...Masselwich b. Breslau, 19.5.90, leg. Schroeter" and the fungus has been determined by Schroeter as "*Empusa radicans*".

Etymology: brevis (Lat.) — short, relation to the length of the primary conidia.

(57.) *Zoophthora canadensis* (MacLeod, Tyrrell et Soper) Remaudière et Hennebert

Zoophthora canadensis (MacLeod, Tyrrell et Soper) Remaudière et Hennebert, Mycotaxon 11: 301. 1980; — *Entomophthora canadensis* MacLeod, Tyrrell et Soper, Canad. J. Bot. 57: 2663-2672. 1979; — *Erynia canadensis* (MacLeod, Tyrrell et Soper) Humber et Ben-Ze' ev, Mycotaxon 13: 509. 1981; — *Erynia* subg. *Zoophthora canadensis* (MacLeod, Tyrrell et Soper) Humber et Ben-Ze' ev ex Ben-Ze' ev et Kenneth, Mycotaxon 14: 467. 1982.

Mycelium inside host's cadavers in form of elongated hyphal segments 8-15 µm thick often with short outgrowths or branches, intermixed with longer hyphae

rather filamentous, 5-11 μm thick. Conidiophores 6-9 μm thick, typically branched. Primary conidia ellipsoid 15-36.5 x 6.5-14.5 μm, av. about 25 x 10 μm, of broadly rounded distal end. Capillispores rather strongly elongate, somewhat crescent-shaped, of av. dimension 33 x 9 μm, with mildly arcute dorsal outline and almost straight or unremarkably sinuose ventral one; distal end usually subacute. Capillary sporophores thin, moderately long — mostly about 2.5-3.5-times longer than capilliconidia. Pseudocystidia undescribed. Rhizoids described as cylindrical with digitately branched, web-like holdfasts and numerous hypal fiaments around host's body. Resting spores globose 29-43 μm, av. 34 μm in diam., covered by walls 2.5-4 μm thick of brown, reticulate, rather thin epispore; they originate on short, neck-like processes, as azygospores.

Distribution and hosts. North America (Canada), on the aphids *Schizolachnus piniradiatae* (Davidson) (*Homoptera*: *Lachnidae*).

Remarks. Formerly — beginning from early 1960[s] of this century — this fungus was identified as „*Entomophthora aphidis* Hoffmann in Fresenius" (Grobler et al. 1962, Remaudière & Hennebert 1980).

58. *Zoophthora crassispora* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia elongata, paulum ramosa, 5-8 μm crassa. Conidiophora 5-8 μm crassa, largiter ramosa, cum ramis conidiogenis cylindratis vel claviformibus, dimensionibus 25-33 x 9-11 μm. Conidia primaria ellipsoidalia vel cylindrata, dimensionibus 25-29 x 8-9.5 μm, in L:D proportionem 2-3. Conidia secundaria breviter ellipsoidalia, in diametrum circa 10 μm. Capilliconidia cornea, utrimque obtusa, cum linea dorsali fortiter convexa, nonnumquam fere semicirculata, et cum linea ventrali paulisper concava, dimensionibus (15-) 22-28 (-30) x (6.5-) 7-8.5 (-9) μm; capilliphora tenuia, 50-65 μm longa. Pseudocystidia circa 10 μm crassa, paulum convergentia, in apice obtusa, 130-160 μm longa. Rhizoidea in pseudorhizomorpha contexta. In imaginibus lepidopterorum Celypha flavipalpana parasitans. In mediis artificialibus luteum continentibus lentissime crescit, sine sporulatione typica; cultura post 1-2 menses moritur. In artificialibus mediis* "PDA" *et* "SA" *non crescit.*

Holotypus. *Specimen numero 1933 b in collectione* ZBS PAN *designatum die 8 mensis Augusti anno 1987 in silva frondosa Bialoviezensi collectum.*

Mycelium in form of hyphal segments or long, tubular, sparingly branched hyphae 5-8 μm thick. Conidiophores of the same thickness, richly branched in top parts; terminal conidiogenous branches cylindric or claviform 25-33 x 9-11 μm. Primary conidia ellipsoid, (25-) 26.5-28 (-29) x (8-) 8.5-9.5 μm, of L:D ratio 2-3.1.

Secondary conidia short ellipsoid of the diameter about 10 μm; only first series of secondary ballospores appeared in prepared material. Capilliconidia regularly crescent-shaped of obtuse ends, with strongly convex dorsal outline, sometimes almost semicircular, and regularly slightly concave ventral line (Fig. 40c); their measurements (15.5-) 22-28 (-30) x (6.5-) 7-8.5 (-8.8) μm; capillary sporophores 50-65 μm long, about 1.5-2 μm thick at the base, then steadily narrowing to 0.7-0.9 μm at tips. Pseudocystidia so thick as the hyphae, 130-160 μm long, rounded at ends. Rhizoids typically in pseudorhizomorphs. Growth on media enriched with egg yolk slow, without typical conidiation; single conidia found in preperad slides were much bigger, 30.5-40.5 x 9.5-10.5 μm, separated from the tips of unbranched hyphae. Growth on SA and PDA limited to inocula (containing residual EY), without any form of sporulation.

Distribution and hosts. On adult moths of *Celypha flavipalpana* (Herrich-Schäffer) (*Lepidoptera*: *Torticidae*), attached to leaves of the hardwood forest undergrowth in the Białowieża National Park, collected on 8 August, 1987.

Remark. The dimensions of the primary conidia and capillispores resemble somewhat those of *Z. bialoviezensis*, whereas considering the hostsit seems to be closer to *Z. geometralis*. Necessary is to compare more materials of these three species.

Etymology: crassus (Lat.) — wide, coarse, relation to the considerable thickness of the primary conidia.

(59.) *Zoophthora crassitunicata* Keller

Zoophthora crassitunicata Keller, Sydowia, Ser. 2, 33: 170. 1980; — *Erynia crassitunicata* (Keller) Humber et Ben-Ze' ev, Mycotaxon 13: 509. 1981; — *Erynia* subg. *Zoophthora crassitunicata* (Keller) Humber et Ben-Ze, ev ex Ben-Ze, et Kenneth, Mycotaxon 14: 467. 1982.

Conidiophores about 6-8.5 μm thick, branched in the top part; conidiogenous cells elongate, bottle-shaped or somewhat clavate, about 35 x 7-8 μm. Primary conidia long ellipsoid to almost cylindric, 25-36 x 8.5-12 μm (av. 31.8 x 9.8 μm), of short, conical papillae and very short, although distinct, slightly constricted over-papillar neck; distal ends obtuse. Capilliconidia elongate, 33-39 x 8-9 μm, somewhat crescent-shaped, with strongly arcuate dorsal outline and the ventral one weakly sinuose, slightly concave, beginning with 1/4 from the base; their distal ends rounded, of distinctly thinner walls; capillary sporophores rather thin, about 70-80 μm long. Resting spores globose 35-56 μm in diam. (av. 43.5 μm), 2-8 nucleate surrounded by two-layered 5-6 μm thick wall, of about 2 μm thick, brown external epispore, appearing smooth at 400 x magnification but with dense minute

knobs visible in histological sections. Pseudocystidia undescribed. Rhizoids present.

Distribution and host. Switzerland, on adult cantharid beetles, probably of the genus *Malthodes*.

Remarks. Thickness of the conidiophores and resting spore wall layers as well as the dimensions of conidiogenous cells have been approximated after Keller's (1980, pl. 2) illustoation.

60. *Zoophthora falcata* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia elongata,* 8-17 μm *crassa, saepe cum tenuibus appendicibus hyphalibus. Conidiophora 5-7.5* μm *crassa, in apice digitose ramosa, ramulae terminales dimensionibus circa 25 x 7-10* μm. *Conidia primaria cylindrata utrimque obtusa, ad hospitem dimensonibus (18-) 18.5-20.5 (-22.5) x (5-) 5.5-6* μm., *in cultura artificiali 21-23* μm *longa. Conidia secundaria minora, crassiora. Capilliconidia solum in cultura artificiali in „PDA" accepta, angusta, plano-convexa vel valde falcata, in apicis parte acuta, dimensionibus 16-27.5 x 3.8-4.8* μm, *L:D proportione 4.8-5.7. Pseudocystidia non multa, cylindrata, diametro 5-6* μm, *in apicibus obtusa, in altitudinem 30-70* μm *supra pseudohymenium excrescunt. Rhizoidea fasciculata, raro singularia, inter partis centralis corporis sclerita excrescunt. Sporae perdurantes ignotae. In formicarum Myrmica laevinodis imagine parasitans. Mycelium in mediis artificialibus bene augetur. Coloniae albae, densae, ad diametrum 1.5-2 cm in medio artificiali* "SDEYA" *per 4 dies, in medio* "PDA" *per 14 dies perveniunt. Sporulatio typica.*

Holotypus. *Specimen numero 1945 in collectione* ZBS PAN *designatum, in silva frondosa prope* Puszczykowo (Wielkopolski Park Narodowy) *die 23 mensis Augusti anno 1987 collectum.*

Hyphal bodies inside host's hemocele in form of elongate segments of uneven thickness 8-17 μm often branched or with thin, hyphal outgrowths. Conidiophores 5-7.5 μm thick, richly digitately branched in terminal parts. Conidiogenous cells cylindric or somewhat clavate about 25 x7-10 μm. Primary conidia cylindric of both ends obtuse, (18-) 18.5-20.5 (-22.5) x (4.7-) 5.5-6.2 μm. Secondary ballospores shorter, of smaller L:D ratio.Capilliconidia not obtained from host insect. Pseudocystidia not numerous, so thick as conidiophores and relatively short, equally narrow, of obtuse ends, sticking uot 30-70 μm over the conidiogenous layer. Rhizoids typical, fasciculate, in thorcical part of the insect.

Growth and sporulation on media containing egg yolk good; 4 day-old cultures attain 15-18 μm in diam. Conidia abundant, typcal, a little longer than from insect (21-23 μm long). On PDA two week-old cultures attain about 20 mm in diam.,

with conidial sporulation appearing only in central part. Around the colony abundant capillispores were formed. Capilliconidia, especially those of first series distinctly bent (Fig. 38c), 16-27.5 x 3.8-4.8 µm, falcate or, the smallest, narrow semilunate. Development and morphology on SA similar, sporulation scarce.

Distribution and hosts. On the ant-worker *Myrmica laevinodis* Nyl. attached to the underside of a leaf of coltsfoot (*Tussilago farfara* L.) in deciduous forest floor vegetation in the Wielkopolski National Park, Puszczykowo, 23 August, 1987.

Remarks. A specimen of *Zoophthora* sp. on a leafhopper was found in the same time on neighbouring coltsfoot leaf. Its conidia were little greater (11.5-) 20-22.5 (-25) x (5.5-) 6-6.3 (-6.5) µm, and pseudocystidia longer — up to 180 µm. Unsuccessful trials to isolate and lack of capilliconidia make impossible full identification of this specimen.

The only record of *Zoophthora* sp. from an ant *Formica* sp. has been given by Petch (1948: 288), who identified it as „*Entomophthora sphaerosperma* Fresenius" in the sense of synonymy with „*E. radicans*".

Etymology: *falcus* (Lat.) — sickle, frequent shape of the capillispores.

61. *Zoophthora forficulae* (Giard) Batko

Zoophthora forficulae (Giard) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 404.1964; — *Entomophthora forficulae* Giard, Bull. Sci. France Belgique 20: 197-224. 1889; *Erynia* subg. *Zoophthora forficulae* (Giard) Ben-Ze' ev, Fundamental and applied aspects of invertebrate pathology, Wageningen, p. 219. 1986; Mycotaxon 27: 268. 1986 (nec *Empusa forficulae* var. *major* — Petch, Trans. Brit. Mycol. Soc. 27: 87. 1944).

Hyphae filling host's body 4-10 µm thick, irregularly branched, with some parts considerably stronger distended even up to 15-21 µm. Conidiophores 6-8.5 µm thick, relatively long and sinuose, richly digitately branched in top parts. Sporogenous cells cylindric or clavate, 25-29 (-34) x 7-9.5 µm, form compact pseudohymenial layers. Primary conidia cylindric of both ends obtuse, (20.5-) 23.5-24 (-27) x (6.5-) 7-7.2 (-8) µm, with hardly marked very short overpapillar constriction (Fig. 39c). Secondary ballospoes of the first and second series similar, smaller and of lower L:D ratio, further series ampulliform or pear-shaped, 19-22 x 7.5-9.2 µm. Capilliconidia fusiform of both sides convex but in profile outline somewhat asymmetric; both ends similarly conically tapered (Fig. 41b). Their first series measure 18.5-23.8 x 5-5.5 µm, further series succesively smaller and smaller till 11.5 x 3.8 µm. Capillary sporophores long and thin, 65-80 x 1-1.2 µm at bases and 0.4-0.6 µm at tips, in final series shorter — 30-50 µm long. Pseudocystidia pretty numerous, 8-16 µm thick at the base and slightly narrowing toward the obtuse tip or almost parallelepipedous. Rhizoids typical. Resting spores unobserved.

The fungus develops well on media enriched with egg yolk, giving in two weeks colonies up to 4.5 cm in diam. with abundant, typical sporulation. The co-

Fig. 40. Capilliconidia of *Zoophthora* spp. of the subgenus *Zoophthora:* a — *Z. ichneumonis,* H — from host-insects, M — from culture on PDA (different collections); b — *Z. obtusa,* from host-insects; c — *Z. crassispora,* from host-insects Białowieża National Park); d — *Z. lanceolata* from nematocerous flies (Białowieża National Park); e — *Z. lanceolata*-like specimen from an adult of *Pteromalidae* (Wielkopolski National Park).

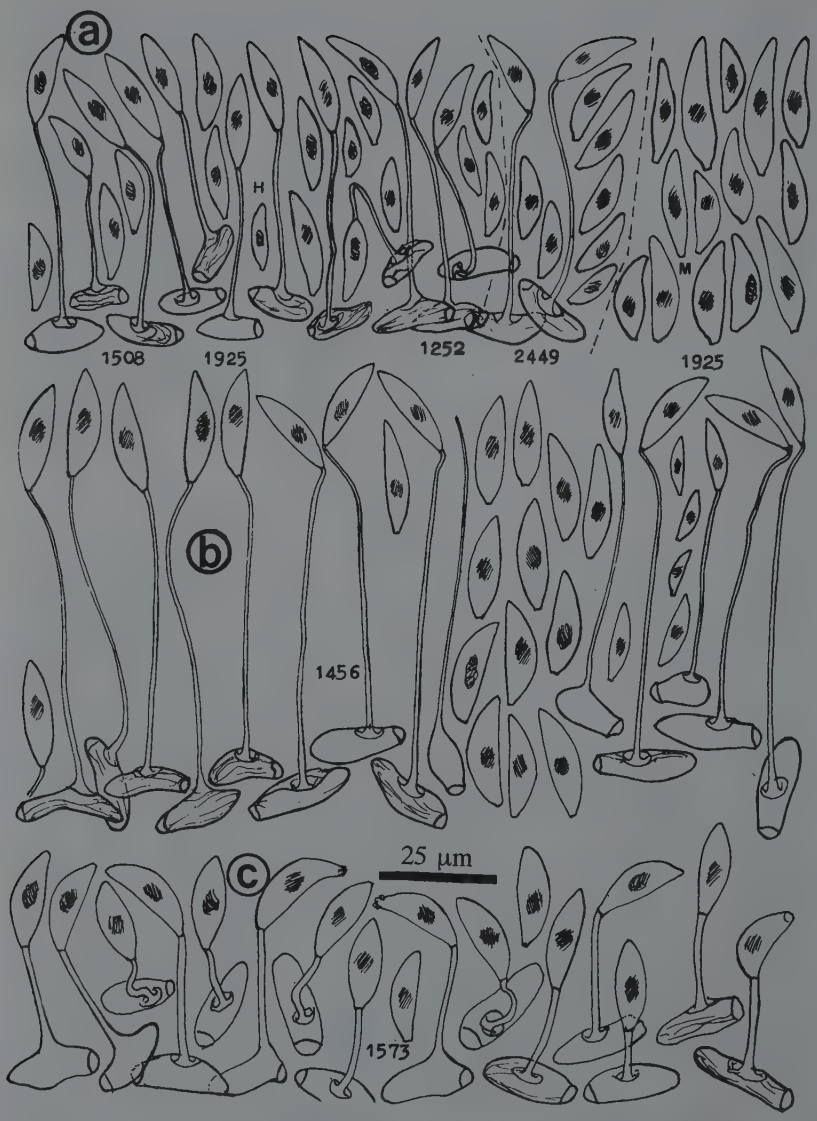


Fig. 41. Capilliconidia of *Zoophthora* spp. subg. *Zoophthora:* a — Z. *miridis*, H — from host-insects, M — from culture on PDA; b — Z. *forficulae* from host-insects; c — Z. *phytonomi* from host-insects (all collections from the Wielkopolski National Park).

lony surface is floccose of dirty-yellow colour, with stronger sporulating, velvety, yellow-brownish zones.

Distribution and hosts. Western and Central Europe, on *Forficula auricularia* L. and *Chelidurella acanthopygia* L. (*Dermaptera*).

Occurrence in Poland. Wielkopolski National Park, on *Chelidurella acanthopygia* — 6 infected specimens collected between 18 September and 4 October 1981.

Remarks. Batko (1966) suggested possible synonymy of *Z. forficulae* with *Z. radicans*. Humber (1981) expressed a doubt sustained by Ben-Ze' ev & Kenneth (1982) whether such a species existed at all. The discovery of the fungus perfectly corresponding with Giard's (1889) descriptions both in morphology and conditions of appearance as well as on closely related (or perhaps the same) host has justified its occurrence and good status of the separate species by Bałazy (1984, 1986). Reexamination of materials collected by Petch (1931) allowed to demonstrate that „*Empusa forficulae* var. *major*" is in reality a separate species of *Zoophthora* subg. *Furia* (Ben-Ze' ev 1986, Humber 1989, Keller 1991 see p. 165).

(62.) *Zoophthora geometralis* (Thaxter) Batko

Zoophthora geometralis (Thaxter) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 405. 1964; — *Empusa* subg. *Entomophthora geometralis* Thaxter, Mem. Boston Soc. Nat. Hist. 4: 170-171. 1888; — *Entomophthora geometralis* Thaxter ex Lakon, Z. angew. Entomol. 5: 176. 1919; — *Entomophthora geometralis* (Thaxter) Gustafsson, Landtbrutshogsk. Ann. 31: 142-143. 1965; *Zoophthora* subg. *Zoophthora geometralis* (Thaxter) Batko ex Batko, Acta Mycol. 2: 18.1966; — *Erynia geometralis* (Thaxter) Humber et Ben-Ze' ev, Mycotaxon 13: 509. 1981; — *Erynia* subg. *Zoophthora geometralis* (Thaxter) Humber et Ben-Ze' ev ex Ben-Ze' ev, et Kenneth, Mycotaxon 14: 467. 1982.

Hyphal bodies as short sections of hyphae, almost round, elongated or branched. Conidiophores digitately ramose. Primary conidia ellipsoid or ovoid 15-22 x 10-12 µm, of L:D ratio varying between 1.5-2. Capilliconidia „almond shaped" of rather little asymmetrically fusiform shape, with the ventral side slightly and dorsal one stronger arcuate convex and distal end conically subacute or acute, after proportions of Thaxter's (1888, pl. 17) drawings about 26-29 x 7-9.5 µm, produced on capillary sporophores about 70-100 µm long. Resting spores hyaline, spherical 28-37 µm in diam., av. 31 µm after Gustafsson (1965: 142), av. 30 µm after Thaxter (1888: 170), hyaline, smooth. Rhizoids mostly in pseudorhizomorphs.

Distribution and hosts. North America (USA) and Northern Europe (Sweden), on small adult moths of the family *Geometridae*.

Remarks. This poorly described species seems to be rather rare. Original materials should be compared with those described under the name *Z. crassispora* (p. 223). The above characteristics has

been compiled on the basis of Thaxter' s (1888) and Gustafsson' s (1965) descriptions and illustrations.

63. *Zoophthora giardii* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia irregulariter elongata, saepe cum appendicibus hyphalibus et hyphis septatis, 5-8 µm crassis, intermixta. Conidiophora crassitudine 6.5-9 mm, cum ramulis conidiogenis lagenaeformibus, in dimensiones 20-25 x 8-10 µm. Conidia primaria cylindrata, dimensionibus 19.5-23.5 x 6-7 µm, utrimque obtusa. Capilliconidia cylindrata cum basis et terminali partibus breviter conicis attenuata, dimensionibus 21-25 x 5-6.5 µm, recta vel leniter inflexa. Pseudocystidia tenui-conica, in longitudinem ad 100 µm. Rhizoidea fortia, fasciculata cum singularibus intermixta. Sporae perdurantes globosae, diametro (22-) 25-29 (-32) µm, sine colore, cum membranis circa 2.5 µm crassis, episporio levi. Mycelium in mediis artificialibus luteum continentibus bene crescit; coloniae per 7 dies ad diametrum 2.5-3 cm, in* „PDA" *— 1-1.7 cm perveniunt. Sporulatio typica. In larvis et imaginibus Orthopterorum Meconema thalassinum parasitans.*

Holotypus. *Specimen numero 1388 c in collectione* ZBS PAN *designatum, in silva frondosa prope* Puszczykowo (Wielkopolski Park Narodowy, *Polonia*), *die 6 mensis Septembris anno 1987 collectum.*

Mycelium filling host's body cavity consists of irregularly elongate hyphal bodies often with outgrowths and thin appendices intermixed with sparsely septate hyphae 5-8 µm thick.Conidiophores 6.5-9 µm thick, digitately branched, with terminal conidiogenous branchlets cylindric or bottle-shaped 20-25 x 8-10 µm. Primary conidia cylindric, 19.5-23.5 x 6-7 µm, of both ends obtuse. Capilliconidia pretty long, 21-25 x 5.5-6.5 µm, of the L:D ratio 3.8, straight or very indistinctly bent, with relatively long almost cylindric central part, rather abruptly conically converging at both ends (Fig. 44a); distal ends blunt. Pseudocystidia narrow conical, not thicker than conidiophores, sticking out about 100 µm over the conidiogenous layer, of obtuse ends. Rhizoids in typical pseudorhizomorphs. Resting spores hyaline or light yellow, spherical, of the diam. (22-) 25-29 (-32) µm, surrounded with 2,5 µm thick wall of smooth epispore. The fungus develops well on media containing EY. The colonies attain 2.5-3 cm in diam. after 7 days. They are compact, at first white to cream, becoming into light yellowish brown colour with age. Conidiation abundant, typical. The hyphae grow deeply into the substrate. On PDA and SA colonies smaller, 1-1.7 cm in diam. after 7 days, with abundant sporulation. Capillispores very numerous and typical, particularly on PDA (Fig. 44a-M).

Distribution and hosts. Western and Central Europe (France, Germany, Poland) on grasshoppers occurring in forest undergrowth.

Occurrence in Poland. On nymphs and adults *Meconema thalassinum* (De Geer), in deciduous forests of the Wielkopolski National Park, protective forest districts Puszczykowo and Jeziory in July and August.

Remarks. The fungus seems to be rather rare. Its previous records may only be suppossed on the basis of illustrations of Giard (1889, pl.V-1) and Stadler (1941, Fig. 4), which show quite identical situations of grasshopper cadavers as those observed by the author of the present review (Fig. 43.). Giard' s (1888; 1889: 217-219) description of *„Polyrhizium leptophyei"* concerns undoubtedly a mixture of saprophytic hyphomycetes developing in old grasshopper cadavers. Such remnants practically devoid of any content except strongly scleritized carapace, sometimes without abdominal parts, overgrown abundantly by dematiaceous hyphomycetes and *Cephalosporium*-like moniliaceous forms were found by the author of the present paper in the Wielkopolski National Park even on 20 September 1988, almost two months after the collection of dead insects of the same species filled with this *Zoophthora*-fungus resting spores. However, in both cases they were strongly affixed to the leaves by numerous rhizoidal pseudorhizomorphs typical for the species of *Zoophthora*. Thus, there is no room for any doubt that Giard' s supposition on a possible entomophthorosis of *Leptophyes punctatissima* (Bosc.) has now been confirmed. It is then justifiable to devote to his memory the true pathogen's name.

Etymology: dedicated for memory of Professor Alfred Giard.

(64.) *Zoophthora humberi* (Aruta et Carrillo) Bałazy,. comb. nov.

Erynia subg. *Zoophthora humbersi* Aruta et Carrillo, Agro Sur. 17: 13, 18. 1989.

Primary conidia narrow ellipsoid 22.5-26.8 x 5.8-8 μm) av. 24,2 ±1.3 x ±0.6 μm) of L:D ratio 2.8-4; papillae short conical delimited by short overpapillar constriction; distal end mildly attenuated with blunt apex. Secondary ballospores shorter and thicker of ellipsoid-rhomboidal outline. Capilliconidia narrow-fusiform of L:D ratio about 6.5, somewhat asymmetric, of very slightly convex ventral outline and smoothly arcuate dorsal side, narrowed into blunt apex, 29-33.3 x 4.3-5.1 μm. Capillary sporophores 35.5-53.3 μm long. Resting spores globose 25.4-34.1 μm in diam. (av. 30.2 ±21 μm), hyaline, smooth, of the wall about 2.5 μm thick. Rhizoids present.

Distribution and host. Chile, Isla Taja, on an adult of *Tipulidae* (*Diptera*).

Remarks. This characteristics is based on the description and illustrations given by Aruta and Carrillo (1989). It should be supplemented by richer material to establish a degree of variability, although there is rather no doubt that the fungus has been correctly treated as a new species.

65. *Zoophthora ichneumonis* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia elongata, dimensionibus 30-80* x *10-19* μm, *cum hyphis tenuioribus, fere aequo-angustis intermixta. Conidiophora 6-8,5* μm

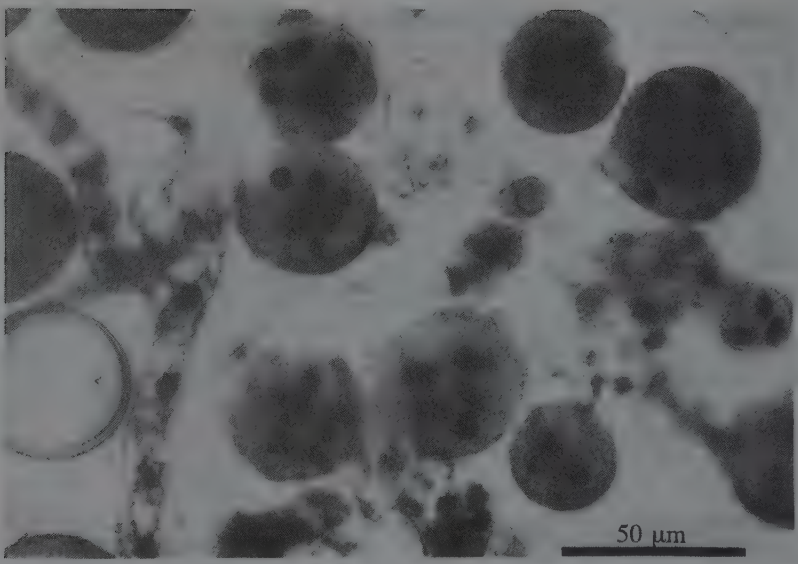


Fig. 42. *Zoophthora phytonomi* — formation of azygospores in artificial culture on SDEYA (a Romanian strain).

Fig. 43. *Zoophthora giardii* — infected individuals of *Meconema thalassinum* De Geer (Wielkopolski National Park).

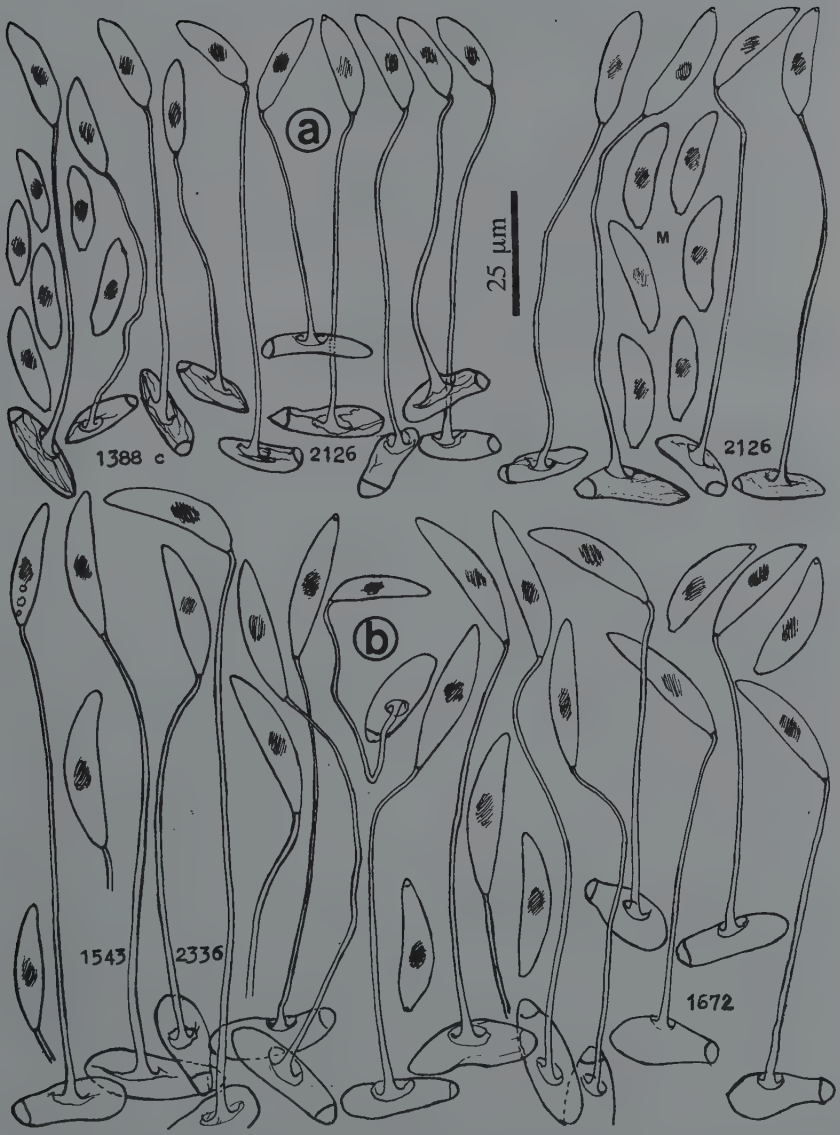


Fig. 44. Capilliconidia of *Zoophthora* spp. subg. *Zoophthora:* a — *Z. giardii* (H — from host-insects, M — from culture on PDA); b — *Z. anglica* from host-insects (both collections from the Wielkopolski National Park).

crassa, digitose ramosa. Conidia primaria cylindrata, in dimensiones (14-) 16-20 (-21) x (4.6-) 5.5-6.5 (-7.5) µm. Conidia secundaria saepe ellipsoidalia vel rhombiformia, minora. Capilliconidia ex hospite variabilia, breviter fusiformia vel anguste amygdaliformia, cum parte distali saepe breviter rostrato-elongata et cum leniter sinuosa linea ventrali, ex cultura artificiali solito anguste amygdaliformia cum elongata, subacuta parte distali, dimensionibus ex insectis 15-19 x 4.5-6 µm, ex cultura 20-28.5 x 5-6.8 µm. Pseudocystidia non multa, brevia, indistincta, in apice obtusa. Rhizoidea typica. Fungus in cultura artificiali bene crescit et sporas edit; coloniae ad diametrum 3-3.5 cm per 7 dies perveniunt. Sporulatio larga et typica in secundo et tertio incrementi hebdomide. In Hymenopterorum familiae Ichneumonidae imaginibus parasitans.

Holotypus. *Specimen numero 2115 in collectione* ZBS PAN *designatum, in silva frondosa Bialoviezensi die 30 mensis Maii anno 1988 collectum (*leg. S. Bałazy*).*

Mycelium inside host's body hyphal or segmented as elongate, often branched hyphal bodies about 30-80 x 10-19 µm., intermixed with thinner hyphae. Conidiophores 6-8.5 µm thick, digitately branched. Primary conidia elongate of obtuse ends, ranging between (14-) 16-20 (-21.5) x (4.5-) 5.5-6.5 (-7.5) µm. Secondary ballospores of the first and second series usually similar or little thicker, in further series of ellipsoid or obtuse rhomboid outline. Capilliconidia obtained from insects variable in shapes from short fusiform to narrow amygdaliform with somewhat beak-like elongated obtuse distal ends and shallowly s-shaped sinuose ventral line; obtained on PDA mostly narrow amygdaliform of subacute elongated distal ends (Fig. 40a). Pseudocystidia few, hardly distinguishable, short conical of blunt apex. Rhizoids in typical pseudorhizomorphs. Resting spores found only in one specimen of *Cratichneumon lanius* Gravenhorst, but unripe, globose, smooth, 22-28 µm in diam., with walls 0.5-2 µm thick, hyualine, filled with granular protoplasm.

Several strains were easily cultured both on media containing EY as well as on SA and PDA. The colonies develop generally well, attaining about 3-5 µm in diam. after 7 days and sporulating abundantly during the second and third week of the development. Neither primary conidia nor capillispores differ from these obtained from infected insect.

Distribution and hosts. On adults of several ichneumonid species (*Cratichneumon lanius* Gravenhorst, *Lissonota* sp., a species of the tribe *Scolobatini* and some unidentified yet specimens), collected in the Białowieża and Wielkopolski National Parks.

Remarks. According to a number of references (Thaxter 1888, Rostrup 1916, Lakon 1919 a, Gustafsson 1965, Bałazy 1982 a, Papierok et al. 1984) the entomophthoralean species were reported from adult ichneumonids as „*Entomophthora sphaerosperma* Fresenius" or *Zoophthora radicans* (Brefeld) Batko [also *Erynia radicans* (Brefeld) Ben-Ze' ev et Kenneth], but seldom only roughly characterized or described. Wider

application of morphology and biometric characteristics from artificial cultures and revision of accessible materials should allow to establish a real variability of strains infecting ichneumonids and their possible diversity or alliances. Some of these strains are hardly separable from species infecting flies (*Zoophthora nematoceris* — p. 240), psyllids (*Z. psyllae* — p. 247) or heteropterous bugs (*Z. miridis* — p. 238), but they should not be identified as *Z. radicans* (Brefeld) Batko.

Etymology: *Ichneumonidae* — host's family name.

66. *Zoophthora lanceolata* Keller

Zoophthora lanceolata Keller, Sydowia, Ser.2, 33: 133. 1980; — *Erynia lanceolata* (Keller) Humber et Ben-Ze'ev, Mycotaxon 13: 509. 1981.

Infected insects filled with irregular hyphal segments of approximate dimensions 25-30 x 9-15 µm, often with irregular branches and outgrowths or longer hyphae 7-10 µm thick. Conidiophores 4-6.5 µm thick, digitately branched; terminal conidiogenous branchlets cylindric or slightly clavate, 15-20.5 x 5.2-6.6 µm, were arranged in dense pseudohymenial layer. Primary conidia ellipsoid or short cylindric, (13.5-) 16.5-19 (-21.5) x (5.5-) 6-6.5 (-8) µm, often little thicker in distal half, of both ends obtuse or with obtusely conical papillae. Secondary ballospores similar. Capillispores narrow lanceolate (Fig. 40d), sharply pointed at tips, 15-32 x 3-5 µm, of L:D ratio 3.8-5, formed abundantly beginning from the first hours of sporulation. Capillary sporophores thin, moderately long. Pseudocystidia sticking up to 120-150 µm, regularly distributed, relatively stout, 10-12.5 µm thick at the height of conidiogenous layer, attenuate to 5-6 µm at obtuse ends; the latter often somewhat inflated to 7-8.2 µm. Rhizoids in typical pseudorhizomorphs. Resting spores globose, 19-29 µm in diam. hyaline, smooth, of wall about 3 µm thick.

Distribution and hosts. Central and Western Europe, on adults of some unidentified species of *Diptera*.

Occurrence in Poland. Białowieża National Park, 3 July, 1982, on small *Diptera*, one specimen of the family *Empididae*.

Remarks. Two strains isolated from these materials grew and sporulate very well on media enriched with egg yolk and show all the features corresponding with Keller's (1980: 168-169) descriptions. Capillispores obtained from insects in moist chambers were generally shorter (18.5-23 x 3.8-4.8 µm) than those described by Keller. Identical capillispores have been obtained from an infected pteromalid specimen (*Hymenoptera: Pteromalidae*) found in the Wielkopolski National Park (Fig. 40e).

67. *Zoophthora larvivora* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia non multa, oblonga, dimensionibus* 25-40 x 7-12 µm, *cum hyphis 7-11* µm *crassis intermixta. Conidiophora in crassitudinem*

6-8 μm; ramulae conidiogenae cylindratae, in dimensiones 32-47 x 7.5-11.5 μm. Conidia primaria cylindrata utrimque obtusa, saepe ad terminum distalem paulo conice, sed non acute, convergentia, dimensionibus (35-) 40-41 (-49.5) x (8-) 8.5-9.5 (-10) μm; L:D proportione fere circa 4.5. Capilliconidia, pseudocystidia et sporae perdurantes ignotae. Rhizoidea typica, fasciculata et singularia. In larva Coleopteroum familiae Cantharidae parasitans.

Holotypus. *Specimen numero 1448 in collectione* ZBS PAN *designatum, in silva frondosa prope* Jeziory *in* Wielkopolski Park Narodowy, *die 6 mensis Septembris anno 1981 collectum.*

Mycelium inside host's body consists of almost equally narrow hyphae 7-11 μm thick, rarely as separate hyphal segments up to 40 μm long. Conidiophores 6-8 μm thick, digitately branched just over insect's cuticle; terminal conidiogenous branches cylindric or indistinctly clavate 32-47 x 7.5-11.5 μm. Primary conidia (Fig. 39d) cylindric with ends obtuse or with distal parts weakly, steadily narrowing towards blunt apex, (35) 40-41 (-49.5) x (7.5-) 8.5-9 (-10.7) μm, of particularly great L:D ratio exceeding commonly 4.5. Secondary ballospores, capilliconidia and resting spores unknown. Pseudocystidia unobserved. Rhizoids in few typical pseudorhizomorphs.

Distribution and hosts. On a larva of cantharid beetle attached to the leaf underside of a herbaceous plant in forest floor, in the Wielkopolski National Park, deciduous hornbeam-oak forest, collected on 6 September 1981. Numerous later trials to find again similar specimens have so far been unsuccessful.

Etymology: *larva, voro* (Lat.) — devour.

Remarks. Petch (1932: 172) described under the name *„Entomophthora (Tarichium) coleopterorum"* a resting spore stage of the fungus infecting adult beetles and producing fasciculate rhizoids. Later (Petch 1944: 88) he identified another fungus, infecting beetle larvae and attaching them with identical rhizoids, as the same species, though there were no resting spores in the latter, but only elongate conidia of the measurements corresponding with those of the above described Polish fungus. Apart from these Petch (1944: 88, 1948: 289) identified under this name a similar fungus found on *Sitona flavescens* Wick (in orig. *Sitones flavescens).* Moreover, on the basis of the a similar structure of rhizoids Petch (1944: 88) suggested that his *„E. (T.) coleopterorum"* may be conspecific with *„Entomophthora (Lophorhiza) carpentieri"* Giard (1888: 303-304), a fungus found in the beetles *Agriotes sputator* and *Elater* sp. However, it was recently shown that the rhizoidal pseudorhizomorphs may be at most treated as a general feature of the subgenus *Zoophthora* and not as a criterion for species identification. Thus Petch' s considerations have been based on at least doubtful characteristic to treat all above insect pathogens as conspecific. On the basis of references and real situations observed in nature the following conclusions or suggestions may be formulated:

1. *„Entomophthora (Tarichium) coleopterorum* Petch, 1932" is really the resting spore stage of a species of *Zoopthora* subg. *Zoophthora* infecting adult beetles, however the lack of host insect identification makes it difficult to suggest a more exact species affiliation.
2. *„Entomophthora (Lophorhiza) carpentieri* (Giard) Turian, 1957" seems to be a result of

the misinterpretation of the *Zoophthora anglica* (= *Z. elateridiphaga*) young azygospores (see p. 210) as round uninucleate conidia by Turian (1957) because the measurements of the resting spores of this species are very close to the given dimensions of the globose monokaryotic conidia.

3. The fungus from *Sitona flavescens* (Petch, 1944, 1948) requires reexamination of its conidia in order to justify the agreement of their measurements with those from the larvae of a beetle. The author of the present review found a species of *Zoopthora* on *Phyllobius* sp. having the conidia very similar, although shorter and plumper.
4. Petch's (1944: 88) fungus from a beetle larva seems to be identical with that found in the Wielkopolski National Park; they cannot be identified as „*Entomophthora coleopterorum* Petch" or in any other combination of this name but described as a new species. The previous author's record (Bałazy 1984) as if the host of the described fungus was a predatory beetle larva of the group *Adephaga* appeared incorrect.

68. *Zoophthora opomyzae* Bałazy et Miętkiewski, n. sp.

Diagnosis. *Mycelium intra insecti corpus e hyphis irregulariter ramosis, 7-10.5 µm crassis cum oblongis vel paulum amoebaeformibus corporibus hyphalibus crassioribus intermixtis constat. Conidiophora 7-9,5 µm crassa, in apice digitosa; ramulae terminales cylindratae vel clavatae, dimensionibus 18-23 x 5.5-7 µm. Conidia primaria cylindrata, utrimque obtusa, in dimensiones (18-) 18.5-20.5 (-23.5) µm. Conidia secundaria breviora, ellipsoidalia vel ovoidea. Capilliconidia tenuia, in apice acuta vel subacuta, dimensionibus 17-26 x 4-5.7 µm, L:D proportione circa 4.5; cum linea dorsali regulariter arcuata, linea ventrali recta vel paulum sinuosa. Pseudocystidia tenuia, usque ad 150 µm longa, 10 µm crassa ad basim, in apice obtusa in crassitudinem circa 5 µm. Rhizoidea typica, fasciculata et singularia. Sporae perdurantes globosae, diametro (21.5-) 23-27 (-29.5) µm, cum parietibus 3-3.5 µm crassis, episporio tenui, levi, fumoso-brunneo. In mediis artificialibus luteum continentibus mycelium bene crescit, primum album, deinde, sporulationis tempore cum superficie cerea, sordido-fulva. Sporulatio typica. In imaginibus Dipterorum Opomyza florum ab mense Augusto ad mensem Octobrem parasitans.*

Holotypus. *Specimen numero 2322 a in collectione* ZBS PAN *designatum, in silva frondosa prope* Jeziory, *in* Wielkopolski Park Narodowy *(Polonia) die 20 mensis Augusti anno 1989 collectum* (leg. S. Bałazy).

Mycelium inside host's body irregularly branched, of the diameter of particular hyphae 7-10.5 µm. Conidiophores 7-9.5 µm thick, abundantly digitately branched in top part. Terminal conidigenous cells cylindric or slightly clavate 18-23.5 x 5.5-6.2 (-7) µm. Primary conidia typically cylindric of both ends obtuse, (18-) 18.5-20.5 (-23.5) x (5-) 5.5-6.5 µm. Secondary ballospospores thicker and thicker in subsequent series, becoming short ellipsoid. Capilliconidia narrow arcuate in

profile outline with the ventral side straight or only unremarkably sinuose, and the dorsal one regularly arcuate convex from wart-like base to a subacute tip (Fig. 35b); first series of the capillispores measure approximately 17-26 x 4-5.7 μm and L:D ratio is about 4.5. Pseudocystidia narrow-conical up to 10 μm thick, with obtuse tips. Rhizoids in typical pseudorhizomorohs. Resting spores spherical (21.5-) 23-27 (-29.5) μm in diam., of the wall about 3-3.5 μm thick, of thin blackish-brown outer layer, giving them smoky appearance.

The fungus develops and sporulates well on artificial media enriched with egg yolk. Neither morphology nor biometrics of the mycelium and spores of fresh isolates differ from these on insects. Production of the capillispores in cultures on PDA abundant.

Distribution and hosts. On very limited number of brachycerous fly species, in the Wielkopolski and Białowieża National Parks and suburban area of Siedlce (leg. R. Miętkiewski).

Remarks. Beginning from the first decade of August 1989 and 1990 local centers of epizootics caused by this fungus in populations of *Opomyza florum* were observed in the Wielkopolski National Park and only individuals of this fly species were infected. Resting spores appeared in cadavers beginning from first days of September.

Etymology: *Opomyza* — generic name of the host species.

69. *Zoophthora miridis* Bałazy et Miętkiewski, n. sp.

Diagnosis. *Mycelium intra hospitis corporem ex oblongis vel irregulariter ramosis hypharum segmentibus, 5-9 μm crassis constat, post hospitis mortem ut hyphae longae crescit. Conidiophora 6-8 μm crassa, in apice ramosa; ramulae conidiogenae terminales dimensionibus 18-22 x 6-7.5 μm. Conidia primaria e hospite cylindrata, utrimque obtusa, in dimensiones (15.5-) 17-20 (-23.5) μm, L:D proportione 3-3.3, ex cultura paulum minora. Conidia secundaria similia, breviora, in L:D proportionem solito non maiorem quam 2.5. Capilliconidia amygdaliformia, dimensionibus 14-22 x 4-6 μm, linea dorsalis ad basim regulariter arcuata, super dimidiam partem leniter convexa et cum linea ventrali in supera parte concava, elongatum apicem, paulo rostratum, formans; infera pars lineae ventralis fere leniter convexa. Pseudocystidia aequo-angusta, circa 100 μm longa, 7-9 μm crassa, in apice obtusa. Rhizoidea typica, fasciculata et singularia. Sporae perdurantes globosae, diametro (20-) 24-26 (-30) μm, sine colore vel flavae, cum parietibus levibus, 2.8-3.5 μm crassis. In mediis artificialibus incrementum bonum et sporulatio larga; coloniae circulatae ad diametrum 2-2.5 cm per 7 dies perveniunt. In larvis et imaginibus Heteropterorum Dicyphus pallidus, raro*

aliorum speciminum propinquorum e familia Miridae et subordine Auchenorrhyncha parasitans.

Holotypus. *Specimen numero 1508 m in collectione* ZBS PAN *designatum, in silva frondosa prope* Jeziory *in* Wielkopolski Park Narodowy *(Polonia), die 20 mensis Iunii anno 1982 collectum* (leg. S. Bałazy).

Mycelium develops inside hosts at first in form of oligokaryotic, elongate or irregularly branched hyphal bodies of the thickness 5-9 μm, giving rise the compact network of tangled, longer hyphae causing mummification of the insects. Conidiophores 6-8 μm thick, richly branched; conidiogenous cells 18-22 x 6-7.5. Primary conidia cylindric (15.6-) 17.3-19.9 (-23.4) x (4.5-) 5.5-6.5 (-7) μm (av. 17.7 ±0.8-19.6 ±1.1 x 5.4 +0,3-6.5 ±0.4 μm) of L:D ratios 3-3.35. Secondary conidia of similar shape but of smaller L:D ratio, usually not exceeding 2.5. Capilliconidia narrow almond-shaped with the dorsal side a little stronger convex, in basal half mildly curved, in terminal part forming together with concave upper part of the ventral line an elongated, narrowing beak. Capillary sporophores thin of moderate length, mostly 25-45 μm long, about 1.2 μm thick at the bases and about 0.5 μm at tips (Fig 41a-H). Pseudocystidia equally narrow of ends obtuse, 7-9 μm thick, stick out up to 100 μm over the conidiogenous layer. Rhizoids in typical pseudorhizomorphs grew as the first external fungus structures both in specimens forming conidial sporulation and resting spores. The latter spherical (20.5-) 24-26 (-30) μm in diam., colourless or light yellow, containing semilunar condensed protoplasm and a big fat globule, surrounded by 2.5-3.5 μm thick wall of smooth epispore. Despite numerous careful examination no typical cases of conjugation have been observed.

The fungus develops well on artificial media containing egg yolk, growing quickly and giving typical sporulation in fresh isolates. Primary conidia from cultures little smaller than obtained from insects. Capilliconidia from the cultures on PDA are typical and very abundant (Fig. 41a-M).

Distribution and hosts. The fungus appeared regularly every year (1978-1992), beginning from the third decade of June till first days of August, causing epizootics in population of juvenile and adult forms of *Dicyphus pallidus* Herrich-Schäffer (*Heteroptera, Miridae*) in forest floor vegetation in the Wielkopolski National Park. In one investigated locality single infected specimens of *Stenodema virens* L. and *S. laevigatum* L., as well as single individuals of unidentified leaf-hoppers have been found. Identical fungus was found on *Lygus* sp., in the vicinity of Siedlce (leg. Dr. R. Miętkiewski).

Remarks. With regard to the morphology the fungus is relatif to *Z. radicans*, however there are no justified records of „*Entomophthora sphaerosperma*" or „*E. radicans*" from Heteropterous bugs. As possibly allied species „*Empusa blissi*" and "*Entomophthora aphrophorae*" could be considered, but real comparisons seem to be impossible. *Z. miridis* differs from *Z. radicans* by morphology of capillispores, size of the primary conidia and narrow, specific host range.

Etymology: *Miridae* — family name of typical hosts.

70. *Zoopthora nematoceris* Bałazy, n. sp.

Diagnosis. *Mycelium e hyphis ramosis 3-10 μm crassis constans in insectorum mortuorum corporibus crescit. Conidiophora 4.5-6.5 μm crassa, digitose ramosa; conidiogenae ramulae terminales leniter claviformes, dimensionibus 20-23 x 6-8 μm. Conidia primaria breviter cylindrata vel ellipsoidalia, in dimensiones (16.5-) 17-19 (21) x 5-6 (-7) μm. Conidia secundaria primariis similia, breviora. Capilliconidia dimensionibus 11-19 (-21) x (4-) 4.8-5.5 μm, L:D proportione 2.5-3.5; arcuata, brevia, in apice obtusa vel subacuta, saepe cum irregulari haptore; linea ventralis leniter sinuosa vel recta et linea dorsalis regulariter convexa. Pseudocystidia fere aequo-angusta vel leniter conica, 50-150 μm longa, ad basim 5-7 μm crassa. Rhizoidea typica, solito fasciculata. Sporae perdurantes ignotae. In mediis artificialibus luteum continentibus mycelium bene augetur. Sporulatio post 7-11 dies incipit. Nonnullae stirpes infirme crescunt et brevi tempore moriuntur. In imaginibus parvorum Dipterorum (Nematocera), plerumque locis umidis, parasitans.*

Holotypus. *Specimen numero 1514 b in collectione* ZBS PAN *designatum, in silva frondosa Bialoviezensi, die 3 mensis Iulii anno 1982 collectum.*

Mycelium inside dead insects and on their surface in form of weakly or moderately branched hyphae 3-10 μm thick, most frequntly 5-7 μm thick, almost parallelopipedous or with scarce puffs 1.5-2.5 μm wider. Conidiophores 4.5-6.5 μm thick, typically digitately branched; terminal conidiogenous branches cylindric or slightly elavate, 20-23 x 6-8 μm. Primary conidia short cylindric or ellipsoid (16.5-) 17-19 (-21) x 5-6 (-7) μm, of L:D ratio 2.9-3.3. They often germinate after several hours with apical outgrowths, similarly as in *Z. aphidis,* not forming secondary spores. Capilliconidia usually of more or less bow-shaped outline in profile, with the ventral sides straight or slightly convex or shallowly sinuose and the dorsal ones almost uniformly arcuate (Fig. 35c); ends obtuse or subacute, often with irregularly shaped terminal structure attaching them to insect cuticle or setae; their measurements are 11-19 (-21) x (4-) 4.8-5.6 μm, of L:D ratio ranging between 2.5-3.4. Capillary sporophores relatively short or of moderate lenght 22-45 μm, about 1.5 μm thick at the bases and 0.5 μm at ends. Pseudocystidia almost equally narrow or conical of the thickness about 5-7 μm, with blunt apex, protruding (50-) 70-120 (-150) μm over the conidiogenous layer. Rhizoids in typical pseudorhizomorphs. Resting spores unknown.

The strains develop well on artificial media containing egg yolk; mycelium white-greyish in some strains dilute; colonies attain the diameter 2.5-3.5 cm in 7 days; in fresh isolates conidial sporulation begins after about 1 week; conidia similar to those obtained on insects, often with single ones of truncate base, separated at ends of unbranched hyphae.

Distribution and hosts. On small nematocerous flies mostly of the families *Sciaridae* and *Fungivoridae* but probably also from others in forest floor vegetation of the Białowieża National Park in spring — mainly end of May and beginning of June, very common in wet habitats. Single specimens found in the Wielkopolski National Park. One strain was obtained from an adult of *Bibio marci* L. (*Bibionidae*) in the municipal Park of Craiova in Roumania on 16 May 1987.

Remarks. This species has probably not been differentiated in collections treated as „*Entomophthora sphaerosperma*" and *Zoophthora radicans* in previous records. However, it differs from typical *Z. radicans* infecting cabbage butterfly caterpillars by measurements and L:D ratio of the primary conidia, shapes of the capillispores and development in artificial cultures.

Etymology: *Nematocera* — name of a group of the order *Diptera* to which host species of the described fungus belong.

71. *Zoophthora obtusa* Bałazy, n. sp.

Diagnosis. *Hyphae paulum ramosae, crassitudine 5-8 μm, hospitis mortui corpus implent. Conidiophora 6-8 μm crassa, digitose ramosa, cum ramulis conidiogenis cylindratis vel clavatis, in dimensiones 20-25 x 7-9 μm. Conidia primaria cylindrata, ad basim et in apice obtusa, dimensionibus (18-) 20-21 (-25) x circa 6 (-6.8) μm; L:D proportione 3.4. Conidia secundaria breviora, ellipsoidalia. Capilliconidia elongata, dimensionibus 17-27 x 4.8-5.7 μm, solito leniter curvata, in basis parte crassiora, cum linea ventrali super basim convexa et supra dimidiam partem leniter sinuose concava; linea dorsalis regulariter arcuata; apex obtusus. Capilliphora tenuia, 35-75 μm longa. Rhizoidea typica, fasciculata et raro singularia. Pseudocystidia et sporae perdurantes non observatae. In imaginibus Dipteroum Brachycerorum parasitans.*

Holotypus. *Specimen numero 2099 in collectione* ZBS PAN *designatum, in horto rustico* Cytrynowo *prope* Mogilno *(in Polonia) die 22 mensis Iunii anno 1975 collectum.*

Hyphae in dead insect equally narrow, 5-8 μm thick, sparingly branched. Conidiophores 6-8 μm thick, richly branched at ends, terminal conidiogenous cells cylindric or clavate, 20-25 x 7-8.8 μm. Primary conidia cylindric of both ends obtuse, (17.6-) 20-21 (-25) x (5.7-) 6.1 (-6.8) μm, of L:D ratio 3.4. Secondary ballospores ellipsoid, shorter. Capilliconidia elongate, bent, the widest in basal half, of ventral side convex over the base and mildly cancave-sinuose towards the blunt, rather broad apex; dorsal side almost regularly arcuate convex; their dimensions 17-27 x 4.8-6.7 μm (Fig. 40b). Capillary sporophores thin 35-75 μm long. Pseudocystidia and resting spores unobserved. Rhizoids typical .

Distribution and hosts. On a brachycerous or calyptrate fly attached to a tree leaf in orchard, Cytrynowo near Trzemeszno (Middle-West Poland), collected on 22 June 1975. An almost

identical specimen found on 11 of June 1989 in the Białowieża National Park on a brachycerous fly produced unconsiderably longer primary conidia (21-) 22-24 (-25) x 6-6.5 μm.

Etymology: *obtusus* (Lat.). — obtuse, blunt — related to the distal end of capillispores.

72. *Zoophthora occidentalis* (Thaxter) Batko

Zoophthora occidentalis (Thaxter) Batko, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12. 404. 1964; — *Empusa* subg. *Entomophthora occidentalis* Thaxter. Mem. Boston Soc. Nat. Hist. 4: 170-171. 1888; — *Erynia occidentalis* (Thaxter) Humber et Ben-Ze' ev, Mycotaxon 13: 509.1981; — *Erynia* subg. *Zoophthora occidentalis* (Thaxter) Humber et Ben-Ze' ev ex Ben-Ze' ev et Kenneth, Mycotaxon 14: 467. 1982.

Hyphal bodies inside hosts at the time of fungus sporulation elongate, sometimes irregularly branched as hyphal segments of very differentiated length, 6-8 μm thick. Conidiophores 5.5-7 μm thick, digitately branched; conidiogenous cells cylindric or clavate 27-40 x 7.8-8.6 μm. Primary conidia (26-) 30-35 (-41) x (6-) 7-8.5 (-9.5) μm, of L:D ratio about 4.2, narrow spindle-shaped or almost cylindrical with conically convergent distal half, forming subacute or narrow rounded ends (Fig. 36b-H); papillae conical or semiglobose. Secondary conidia (Fig. 36b-S) usually shorter and thicker with sides more and more distinctly convex in consecutive series, becoming long ellipsoid or ovoid. Capilliconidia thickly almond-shaped, the thickest in the basal half, or somewhat crescent-shaped, 17-25 x 6-7.7 μm, of the ventral outline slightly concave or sinuose, seldom straight and the dorsal one almost semicircularly convex, often with short, obtuse or subacute beak bent on the ventral side (Fig. 36b-K). Capillary sporophores thin, 55-85 μm long. Pseudocystidia conical, or almost cylindrical, 7.5-15 μm thick at the base, narrowing to 5.5-6.5 μm at blunt apex, protruding singly to about 80-110 μm over the conidiogenous layer. Rhizoids typical form 1-3 pseudorhizomorphs and several single ones on dying hosts. Resting spores globose, (20-) 24-30 (-32) μm in diam., hyaline, smooth, of the wall about 3-3.5 μm thick.

The strains of this fungus develop and sporulate well on artificial media containing egg yolk; the primary conidia are similar to those from insects. Capilliconidia are abundantly produced around the colonies on PDA, on which the fungus develops slowly giving small round, white colonies (Miętkiewski et al. 1981).

Distribution and hosts: North and South America, Europe, Asia, on several species of aphids in the majority unidentified.

Occurrence in Poland. Wielkopolski National Park, in deciduous forest floor vegetation on *Capitophorus similis* v. d. Goot *Impatientium asiaticum* (Nevsky) and *Sitobion fragariae* (Walker). Batko' s (1964: 130) record from the Białowieża National Park was later corrected as a result of the species misidentification (Batko 1966 b: 7).

Remarks. As in the majority of the species belonging to the subgenus *Zoophthora* particular specimens described and determined as *Z. occidentalis* show some range of variability in micromorphology, mainly biometrics. It is, however, impossible to decide about some taxonomical diversity of the species until the ranges of variability of particular species are determined. Thorough analyses of the dimensions and shapes of the primary conidia in specimens obtained from the Wielkopolski National Park show the simultaneous presence of strains which can be identified both as *Z. occidentalis* and *Z. phalloides* Batko in the same time and on the same host — *Capitophorus similis*. It seems to be necessary to revise all accessible materials from aphids identified as „*Entomophthora sphaerosperma*", *Zoopthora radicans*, *Z. occidentalis* and *Z. phalloides* and compared them with the features of other species recently described as aphid pathogens.

(73.) *Zoophthora orientalis* Ben-Ze' ev et Kenneth

Zoophthora orientalis Ben-Ze' ev et Kenneth, Phytoparasitica 9 (1): 33-42. 1981; — *Erynia orientalis* (Ben-Ze' ev et Kenneth) Humber, Ben-Ze' ev et Kenneth in Humber et Ben-Ze' ev, Mycotaxon 13. 509. 1981.

Conidiophores digitately branched. Primary conidia narrow-ellipsoid to almost cylindric, 23.7-34.8 x 6.3-10.3 µm (av. 27.1 x 8.4 µm), of L:D ratio 3.2-3.3; both ends broadly obtuse. Secondary conidia shorter, ellipsoid or pyriform. A capilliconidium illustrated in photograph like Hungarian plum fruit, of blunt apex with the ventral outline hardly convex and the dorsal one regularly arcuate; both lines abruptly bent to the basal wart; the dimensions 24.5-29.2 x 5.5-10.3 µm. Capillary sporophores rather thick — at the base about 2 µm, at ends 1-1.5 µm and 50-60 µm long. Pseudocystidia characteristic, conical with somewhat inflated tips, usually divided by one cross-wall, 15-20 µm wide at the level of conidiogenous cells and about 3-4 µm thick in subapical part, sticking over the pseudohymenial layer about 150 µm. Rhizoids and resting spores unobserved.

Distribution and host. Israel, on *Aphis citricola* v. d. Goot (*Homoptera: Aphididae*), known only from the type locality.

Remarks. Some measurements in the above description were estimated by means of comparison of particular elements of Ben-Ze' ev & Kenneth' s (1981a, figs. 1-5) drawings. Unfortunately there is no mention of morphology of vegetative mycelium and a photograph of only one capillispore is shown, so the original description should be supplemented.

74. *Zoophthora petchii* Ben-Ze' ev et Kenneth

Zoophthora petchii Ben-Ze' ev et Kenneth, Entomophaga 26 (2): 140-141. 1981; — *Erynia* subg. *Zoophthora petchii* (Ben-Ze' ev et Kenneth) Ben-Ze' ev et Kenneth, Mycotaxon 14: 467.1982.

Mycelium filling mummified host's body consisting of elongate, somewhat irregularly branched hyphal bodies about, 40-80 x 12-20 µm, from which rather

stout hyphae of uneven thickness 6.5-12 µm protrude. Conidiophores richly branched in typical mode. Primary conidia (20.5-) 23-25 (-30) x (6.5-) 7-7.5 (-9) µm, of L:D ratio 3.1-3.3. Secondary ballospores shorter, of L:D ratio gradually smaller in consecutive series. Capilliconidia of a peculiar shape, round-ovoid in the basal half, then elongated into relatively thick and short obtuse beak, bent on the ventral side; their dorsal outlines are regularly semicircular whereas the ventral strongly sinuose, convex in the basal and concave in subapical parts (Fig. 38a); their dimensions are 14-18 x 6.3-9.0 µm. Capillary sporophores thin, 30-55 µm long. Pseudocystidia unobserved. Rhizoids typical. Resting spores hyaline, smooth, globose, 24-35 µm in diam., of the walls about 3 µm thick.

One strain from *Javesella pellucida* (F a b r.) isolated on SDEYA developded and sporulated well, forming white, circular colonies about 2 cm in diam. after 2 weeks. No remarkable differences in hyphae and conidia in relation to those from insects have been stated.

D i s t r i b u t i o n a n d h o s t s. Western and Central Europe; on leaf-hoppers, *Philaenus spumarius* and some other, unidentified.

O c c u r r e n c e i n P o l a n d. Wielkopolski National Park, Konin (Central Poland); Turew near Leszno (Middle West Poland); on *Cercopidae, Delphacidae, Jassidae*; identified species: *Philaenus spumarius* and *Javesella pellucida.*

R e m a r k s. As in the majority of *Zoophthora* strains the specimens from different localities or host insects shows some slight differences in micromorphology but the peculiar shape of the capillispores allow to determine easily this species. The capillispores of the strain 1700b from an unidentified small plant-hopper found in the Wielkopolski National Park were regularly thinner and with and apical beaks only slightly bent (Fig. 3a-1700b). The status of this species has been thoroughly discussed by B e n-Ze' e v & K e n n e t h (1981b).

75. *Zoophthora phalloides* B a t k o

Zoophthora subg. *Zoophthora phalloides* B a t k o, Acta Mycol. 2: 7-23. 1966; — *Erynia phalloides* (B a t k o) H u m b e r et B e n-Z e' e v, Mycotaxon 13:505. 1981; — *Erynia* subg. *Zoophthora phalloides* (B a t k o) H u m b e r et B e n-Z e' e v ex B e n-Z e' e v et K e n n e t h, Mycotaxon 14: 467. 1982.

Primary conidia long cylindric of both ends obtuse, 32-40 (-48) x 11-13-14 µm, with papillae so wide as conidium diameter. Secondary conidia shorter, ellipsoid. Capilliconidia about 18 x 7 µm, produced on capillary sporophores 80-120 µm long and 1.5-2.5 µm thick (at the base). Pseudocystidia not thicker than conidiophores, equally narrow, round at tips. Rhizoids typically coalescent into pseudorhizomorphs. Resting spores unknown.

D i s t r i b u t i o n a n d h o s t s. Central and Western Europe, North America; on different species of aphids.

Occurrence in Poland. Białowieża National Park (type locality) on *Microlophium evansi* Theobald (*Aphididae*).

Remarks. There may be some confusions, errors or mistakes as concerns identification of *Z. phalloides*. Batko's (1966 a) description — quoted above — is neither precise nor complete in relation to contemporary requirements of the criteria for species differentiation in the subgenus *Zoophthora*. Particulary unfortunate is the lack of morphology or illustration of capillispores. Moreover, the measurements of the primary conidia are not adequate to the figures as comparing with the scale given by Batko (1966 a, figs. 1-50). There are no spores as long as 40 µm and thicker than 9 µm among those presented in this drawing. Reexamination of the holotype prepared slide obtained from Dr. A. Batko has shown, that the primary conidia measurement range is (25.5-) 28.5-29.5 (-36) x (6.5) 7.4-7.6 (9.1) µm (av. 29 ±1.98 x 7.5 ±0.45 µm), which corresponds almost perfectly with Batko's drawings. Unfortunately no other elements of mycelium or secondary sporulation type have been found in this material. Remaudière et al. (1976) reported similar measurement range for French strains obtained from aphids and indentified as *Z. phalloides*. On the other hand, in materials collected in the Wielkopolski National Park in the same locality, time and host, particular specimens show similar measurements of the primary conidia and shapes of capilliconidia, whereas the primary conidia with conically narrowed distal ends occured abundantly in some strains or were lacking at all in others. Also the skeetches of capilliconidia of *Z. occidentalis* and *Z. phalloides* presented by Remaudière and Hennebert (1980: 306) do not show any essential differences. In this situation the only criterion to differentiate these species is the shape of the primary conidia, but this basis may appear too weak for species separation in this, rather variable, group of fungi. So the only possible way to solve this problem is a careful reexamination of all accessible materials and exact investigation of new collections.

76. *Zoophthora phytonomi* (Arthur) Batko

Zoophthora phytonomi (Arthur) Batko, Bull. Acad. Pol. Sci., Ser. Sci.Biol. 12: 404. 1964; *Entomophthora phytonomi* Arthur, Bot Gaz. 11: 14-17. 1886; — Fourth Ann. Rep. N. Y. Agric. Exp. Sta. (1885): 258-262. 1886; — *Erynia phytonomi* (Arthur) Humber, Ben-Ze'ev et Kenneth in Humber et Ben-Ze'ev, Mycotaxon 13: 509. 1981; — *Erynia* subg. *Zoophthora phytonomi* (Arthur) Humber, Ben-Ze'ev et Kenneth ex Ben-Ze'ev et Kenneth, Mycotaxon 14: 467. 1982.

Hyphal bodies at the early period after host's death 10-85 x 8.5-12 µm, protruding into longer and somewhat irregularly branched hyphae, 4-10 µm thick, but in some points thicker up to 15 µm. Superficial hyphae and conidiophores 6.2-9.5 µm thick, the latter digitately branched at ends. Conidiogenous cells about 30 x 7-8 µm. Primary conidia long ellipsoid or almost cylindric of obtuse ends, often of obtuse fusiform outline, (20-) 23-26 (-28.3) x 6.5-7.2 (-8.3) µm, of L:D ratio about 3.5. Secondary conidia, especially those of further series, somewhat pyriform, with narrow, convex papillae. Capilliconidia 20-25 x 6.7-8 µm, the thickest in half of their height, obtuse almond-shaped or later of the form of Hungarian plum, with the tip blunt or at most subacute (Fig. 41c). Capillary sporophores short, 20-30 µm, relatively thick — about 2.5 µm at bases and about 1-1.2 µm at tips. Pseudocystidia conical 8-11 µm thick at bases, converging to 3-4 µm wide blunt ends,

sticking out 40-80 µm over the conidiogenous layer. Rhizoids in typical pseudorhizomorphs, additionally with few single ones. Resting spores globose, (27.5-) 30-36 (-39) µm in diam. 4-16-nucleate, surrounded with 3.8-5.2 µm thick wall of unevenly rough, black-brown epispore, in some parts verruculose; they are formed by lateral budding of the hyphal bodies, without precedent conjugation.

Colonies of this fungus grew slowly on artificial media attaining 8-10 µm in diam. after two weeks. The most of the aerial hyphae were procumbent on the surface of substrate, as a delicate, cobwebby, white to yellowish tissue with dilute margins. Submerged hyphae were irregular, with numerous polymorphic puffs up to 18 µm wide. Conidial sporulation did not appear; resting spores appeared in one Romanian strain in fresh cultures, about three weeks after inoculation. Vitality decline in artificial cultures rather quick, after about 12-15 months. No growth on PDA.

Distribution and hosts. Europe, Asia, Australia, North America, on larvae and pupae of alfalfa weevils (*Phytonomus punctatus F., Ph. variabilis* Herbst).

Occurrence in Poland. Common in the majority of checked alfalfa fields, especially in 3rd or 4th year old cultures, often epizootic: Pomerania (vicinity of Kłecko and Chojnice), vicinity of Poznań, Wielkopolski National Park, Lubin near Mogilno, vicinity of Lublin).

Remarks. There was some confusion in identification of this fungus since Thaxter (1988: 172) treated it as identical with „*Empusa* subg. *Entomophthora sphaerosperma*" and the latter name was applied for this species until 1980s. It is Batko (1966: 11) who payed attention to the complex character of the fungus identified as „*E. sphaerosperma*", treating simultaneously „*Entomophthora (Tarichium) punctata*" Garbowski (1927 and „*E. (T.) coleopterum*" Petch 1932, as resting spore stages of *Z. phytonomi*. On the other hand Ben-Ze' ev and Kenneth (1980) stated that the appearance of resting spores of „*Entomophthora (Tarichium) phytonomi*" Jaczevskii and „*E. (T.) punctata*" Garbowski (1927) is identical with that of *Conidiobolus osmodes* Drechsler (1954). These authors obtained cultures of the latter species from such resting spores. Moreover, in culture of *Z. phytonomi* they observed subhyaline, almost smooth resting spores of the dimensions comparable with those of *C. osmodes*. The coincidence of the entomophthoroses caused by *Z. phytonomi* and *C. osmodes* has been confirmed by Papierok et al. (1986). The author of the present review did not study occurrence of *C. osmodes* in alfalfa fields with the weevil larvae affected by entomophthoroses, but found often normal rough or verrucose, dark resting spores — identical with those of *C. osmodes* containing, however, typical entomophthoroid nuclei in numbers 4 to about 18. In one culture obtained from the conidia of *Z. phytonomi* in Romania (Oltenia Distr. near Craiova) there were formed typical resting spores comparable with those described by Ben-Ze' ev and Kenneth (1980), of rough and blackish epispore when ripe (Fig. 42). Also, if freshly infected larvae of *Phytonomus* spp., showing typical symptoms of the entomophthorosis caused by *Z. phytonomi* (cream or salmon in color, mildly mummified, attached by pseudorhizomophs of rizoids to leaves) were transferred to a laboratory rearing in glass cylinders, they did not produce conidia, but their hyphal bodies transformed into the azygospores of the same shapes and sizes. One can suppose on this basis that the conclusion of Ben-Ze' ev and Kenneth (1980: 184) about the high mortality of *Phytonomus* larvae caused by *C. osmodes* in Israel should be confirmed by the karyological study on the resting spores.

77. *Zoophthora psyllae* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia irregulariter oblonga, dimensionibus 18-30 x 12-20 μm, cum hyphis paulum ramosis, 3.5-7 μm crassis intermixta. Conidiophora 4.5-6.5 μm crassa, cum typicis ramis digitosis in partibus terminalibus; cellulae conidiogenae dimensionibus 20-25 x 6.5-7.5 μm. Conidia primaria cylindrata, utrimque obtusa, ex hospite in dimensiones (15-) 17-20 (-22) x (5.5-) 6-7 (-8) μm, ex cultura similia, sed paululum crassiora, plus minusve 6.5-7.5 μm crassa. Conidia secundaria breviora, ellipsoidalia vel ovoidea. Capilliconidia typica, amygdaliformia, dimensionibus 14-20.5 x 5.5-6.2 μm; L:D proportione 2.6-3.3; linea ventralis sinuosa, ad basim leniter convexa, in parte subapicali in concavam transiens; linea dorsalis arcuata, convexa, plerumque in brevem rostram, in ventralem directionem vergentem paulum elongata. Capilliphora tenuia, 25-60 μm longa. Pseudocystidia aequo-angusta, dimensionibus 150-250 x 8-9 μm, in apice saepe leniter crassiora (usque ad 10.5 μm). Rhizoidea typica, fasciculata cum singularibus monohyphalibus. Sporae perdurantes ignotae. In mediis artificialibus luteum continentibus coloniae solito lente et male crescunt, solum nonullae bene augentur ad diametrum 2-2.5 cm per 7 dies pervenientes. Sporulatio typica, post 7-11 dies incipit. In nymphis et imaginibus Homopterorum, ordo Psyllodea, parasitans.*

Holotypus. *Specimen numero 1939 d in collectione* ZBS PAN *designatum, ex imagine Trioza urticae in folio Urticae dioicae in silva frondosa Bialoviezensi die 7 mensis Augusti anno 1987 collectum* (leg. S. Bałazy).

Mycelium filling host's body, comprises irregularly ovoid ellipsoid or more irregular, but not ameboid, elongate hyphal bodies, 18-30 x 12-20 μm, and a network of thin, moderately branched hyphae 3.5-7 μm thick. Conidiophores 4.5-6.5 thick, typically branched at ends; conidiogenous cells 20-25 x 6.5-7.5 μm. Primary conidia cylindric of obtuse ends (15-) 17-20 (-22) x (5.5-) 6-7 (-7.8) μm. Secondary conidia similar, in consecutive series becoming more and more ellipsoid and ovoid with arcuate convex sides. Capilliconidia typically almond-shaped, of ventral side weakly sinuose convex in basal, and concave in upper part, forming with the uniformly arcuate dorsal outline short, obtuse beak, somewhat bent on the ventral side (Fig. 38b); their dimensions are 14-20.5 x 5.5-6.2 μm, of L:D ratio 2.6-3.3. Capillary sporophores thin 25-60 μm long. Pseudocystidia equally narrow, 8-9 μm thick, somewhat clavate widened at ends up to about 10.5 μm, 150-250 μm long. Rhizoidal pseudorhizomorphs thin, 1-3 on one host individual, composed of about 10-25 hyphae. Resting spores unknown.

The fungus grows rather hardly in cultures but some strains develop well on artificial media containing egg yolk, forming in submerged mycelium polymorphic hyphal bodies of rather rounded forms, from which superficial, almost equally nar-

row, 7-9 µm thick hyphae protrude. Single not typical, pear-shaped or lageniform conidia are formed on ends of unbranched hyphae in 6-10 day old cultures, and subsequently normal typically branched conidiophores and conidia are abundantly produced; primary conidia a little thicker than obtained in damp chambers from insects, 6.5-7.3 µm thick (Fig. 39 B).

Distribution and hosts. On *Trioza urticae* L. (*Homoptera, Psyllidae*), common in July and August on the underside of the nettle leaves, Białowieża National Park, Wielkopolski National Park, Czempiń and Babki near Poznań, observed regularly every year. In June-July 1993 found in South Germany near Laufen (Bavaria).

Remarks. After the morphology the fungus is very close to *Z. radicans*, differing from it by the shape of capilliconidia, especially those from insects. The records of „*Entomophthora sphaerosperma*" from *Psylla mali* Schmdb. (Dustan 1924, Eremeeva 1925) concern probably the same fungus.

Etymology: *Psyllidae* — family name the host species

78. *Zoophthora tachypori* Bałazy, n. sp.

Diagnosis. *Corpora hyphalia elongata, dimensionibus 25-80 x 9-15 µm, saepe cum ramulis brevibus irregulariter distributis. Conidiophora 6.5-12 µm lata, supra ramosa; ramulae conidiogenae cylindratae, 20-24 x 6-7 µm. Conidia primaria cylindrata, raro paulo subfusiformia, dimensionibus (18-) 19.5-21.5 (-22) x 5.5-6 (-6.5) µm. Capilliconidia fusiformia, in dimensiones 20-25 x 5-5.5 µm, asymmetrica, cum distali parte conica, subacuta; linea dorsalis paulo sed regulariter arcuata, linea ventralis recta vel leniter sinuosa — in parte subbasali convexa, in supera parte concava. Capilliphora tenuia, 40-50 µm longa. Pseudocystidia conica, 30-80 (-120) µm longa ad basim 8-12 µm lata, in apice obtusa. Rhizoidea in pseudorhizomorpha aggregata et singularia, typica. Sporae perdurantes ignotae. In imaginibus Coleopterorum Tachyporus sp. (Staphylinidae) parasitans.*

Holotypus. *Specimen numero 2389 a in collectione* ZBS PAN *designatum, in silva frondosa* Jeziory *prope Posnaniam (Polonia) die 23 mensis Iunii anno 1992 collectum (*leg. S. Bałazy*).*

Hyphal bodies in host's cadavers elongate, 25-80 x 9-15 µm, often with short outgrowths and branchlets. Superficial hyphae and conidiophores 6.5-12 µm thick, the latter richly digitately branched; ultimate sporogenous branches about 20-24 µm long, cylindric or slightly widened near the top, 6-7 µm thick. Primary conidia cylindric, seldom somewhat subfusiform, (18-) 19.5-21.5 (-22) x 5.5-6 (-6.5) µm. First series of secondary ballospores of the same form and size. Capilliconidia oblong fusiform, 20-25 x 5-5.5 µm, of the dorsal outline mildly but uniformly arcuate, and the ventral line downwards uremarkably convex, upwards straight or with

hardly remarkable concavity below the tip; upper part conical, end subacute. A number of capillispores obtained in moist chamber from the specimen collected on 28 July 1991 had nodulose protuberance in upper part of the dorsal side giving them peculiar appearence (Fig. 36c). Capilliphores thin, mostly 40-50 µm long. Pseudocystidia conical of obtuse ends, about 30-80 (-120) µm long and 8-12 µm thick at the level of conidiogenous layer. Rhizoids in one or two pseudorhizomorphs growing from thoracical part and a number of monohyphal ones protruding between obdominal sternites. Resting spores unknown.

The fungus develops and sporulate well in artificial cultures on media containing EY. One week old cultures attain about 2 cm in diam. at the temperature 20°C. Mycelium at first white and floccose, after 4-5 days becomes cream and the colony surface covers with lanose layer of conidiogenous elements forming pseudohymenium. Abundant sporulation persists over 1 month. The conidia do not differ from those produced on insects.

Distribution and hosts. On small staphylinid beetles (*Coleoptera: Staphylinidae*) of the genus *Tachyporus*, attached to underside of leaves in the forest floor vegetation of a hardwood forest, Wielkopolski National Park, protective district Jeziory, found in June and July 1991 and 1992.

Etymology: *Tachyporus* — generic name of the host insect.

(79.) *Zoophthora viridis* Keller

Zoophthora viridis Keller, Sydowia 43: 104. 1991.

Hyphal bodies elongate, filamentous or with wart-like outgrowths, about 7-9 µm thick. Conidiophores about 7.5-11 µm thick, typically branched at ends. Primary conidia on insects (18-) 21-26 (-30) x 96-) 8-9 (-11) µm, cylindrical to subfusiform, with rounded or conical papilla 5-5.5 µm wide, in culture greater, 22-45 x 7-15 µm. Secondary ballospores shorter and thicker, 13-20 x 8-11 µm. Capilliconidia fusiform, on insects 22-35 x 5-7 µm, in cultures longer 29-48 x 6-9 µm, of the dorsal side slightly arcuate and ventral one almost straight; apex obtuse or subacute; capilliphores slender (40-) 50-70 (-120) µm long, at the base about 2 µm thick. Pseudocystidia not numerous, short, conical, not thicker than conidiophores. Rhizoids mostly in typical pseudorhizomorphs. Zygospores globose (22-) 26.5-28.5 (-360 µm, colourless, of smooth wall about 2.5-5 µm thick, 9-21-nucleate. Aerial mycelium both on insects and in cultures light to dark green. Growth in artificial cultures fairly rapid, particularly on media enriched with EY.

Distribution and hosts. Western Europe (Switzerland and Southern Germany), on nymphs and adults of *Notostira elongata* Geoffr. (*Heteroptera*: *Miridae*).

R e m a r k s. This fungus was previously identified as *Zoophthora elateridiphaga* because of green colour of mycelium and great morphological resemblance to the species infecting *Agriotes* spp. (K e l l e r 1982). The main differences are the smaller average size of the primary and secondary conidia as well as capillispores and zygospores. Moreover the primary conidia of *Z. viridis* are the thickest in the central diameter and somewhat narrowed towards the base and distal end, which give them obtusely subfusiform shape, whereas those of *Z. anglica* (=*Z. elateridiphaga*) are rather distinctly cylindric, of semispherically rounded tip.

Form-genus *Tarichium*. C o h n

Tarichium C o h n, Beitr. Biol. Pflanz. 1 (1): 58-86. 1870; — L a k o n, Z. Pflanzenkrakh. 25: 257-272. 1915; — *Entomophthora* (*Tarichium*) M a c L e o d et M ü l l e r-K ö g l e r, Mycologia 62: 33-66. 1970.

Fungal structures filling host's body cavity in form of durable resting spores of zygospore or azygospore type, occasionally also produced in the external mycelium. They are spherical, ovoid, ellipsoid or polyhedral in shape and consist of globose or subglobose central part of condensed protoplasm, containing one to many nuclei and one or more fat globules. Surrounding walls are thick, two or three-layered with smooth, rough, echinulate, spinulose, warty or otherwise ornamented surface, hyaline or coloured. Other elements of mycelium like hyphal bodies, hyphae and rhizoids may occur.

The affiliation to families is impossible since the character of nuclei has so far been recognized only for very limited number of forms. Identification is possible only in cases when dead invertebrates specimens are collected before advanced decay, so the majority of forms known until now is connected with arthropods of relatively strongly chitinized or sclerotized exoskeleton. With regard to the morphology there occur a number of hardly distinquishable forms which, however, often should not be identified as the same species. On the other hand a number of typical entomophthoraceous species may be identified on the basis of peculiar resting spore characteristics.

Type species: *Tarichium megaspermum* C o h n.

Key for species-forms

1. Occurring in insects 2
1*. Occurring in mites 23
2. Epispore smooth 3
2*. Epispore ornamented at least on a part of spores 8
3. Spores hyaline, light yellow or golden yellow 4

3*. Spores brown coloured, often chestnut brown in mass 5

4. Spores 20-30 µm in diam., with epispore 3-4 µm thick; fasciculate rhizoids often present; in different insect species . . . . . *T. spherospermum*-complex, p. 266

4*. Spores 35-45 µm in diam. of 2-2.5 µm thick epispore in the plant-hopper *Euacanthus interruptus (Cicadellidae)* . . . . . *T. jaapianum*, p. 261

5. Spores globose, rarely ovoid, their minimum diameter exceeds 30 µm and the maximum is about 50 µm or more; fasciculate rhizoids usually present 6

5*. Spores globose 14-35 µm in diam., rhizoids — if present — monohyphal with terminal disc-like holdfasts; in adult flies 7

6. In cantharid beetles *Rhagonycha lignosa* and *Rh. fulva*; spores hazel or brown 43-55 (-62) µm in diam. or subglobose 61-68 x 56 um . . . . . *T. rhagonycharum*, p. 265

6*. In aphids *Anoecia* spp. on *Cornus*; spores black and brown 30-52 µm in diam., mostly 37-41 µm, globose . . . . . *Zoophthora aphidis*, p. 211 subg. *Zoophthora*

7. Spores 14-20 µm in diam. . . . . *T. cyrtoneurae*, p. 259

7*. Spores 30-35 µm in diam. . . . . *T. calliphorae*, p. 257

8. Spores hyaline 25-35 µm, with epispore delicately shallowly pitted; in flies . . . . . *T. subpunctulatum*, p. 267

8*. Spores coloured 9

9. Spore colours rather bright, from yellow, reddish orange, light tan to pale brown in mass 10

9*. Spore colours dark, from hazel brown (deep green brown), dark brown to almost black 12

10. Spores globose to broadly ellipsoid 26-48 x 24-32 µm, bright, with walls 1-1.5 µm thick of verruculose surface; in pupae of *Cimbex* sp. (*Hymenoptera: Cimbicidae*). . . . . *T. cimbicis*, p. 258

10*. Spores light yellow-browhish or with tint of orange, with strongly aculeolate or densely conically verrucose epispore 11

11. In lauxaniid flies; spores 30-50 µm in diam., with dense, sharp conical or somewhat obtuse warts on epispore . . *Zoophthora echinospora*, p. 185 subg. *Neopandora*

11*. In larvae and pupae of *Cleonus punctiventris* (*Coleoptera*: *Curculionidae*); spores globose 25-30 µm, with aculeolate epispore . . *T. cleoni*, p. 259

12. Spores hazel or dark brown in mass 13

12*. Spores black in mass but sometimes of some shades of brown when occurring singly 16

13. Spores hazel, globose or subglobose, 36-40 µm, epispore 2.5 µm thick of the surface striate with irregular grooves; in caterpillars of *Eurois occulta* (*Lepidoptera: Noctuidae*) . . . . . *T. lavrovium*, p. 262

13*. Spores dark brown but without hazel tints 14

14. Spores spherical, subspherical, ovoid or pyriform, of the greatest diameter 35-56 µm, with verrucose epispore; rhizoids fasciculate; in adult beetles . . . . . *T. coleopterorum*, p. 259

14*. Spores regularly globose, exceptionally single a little pyriform . . . 15

15. Spores smooth, 41-48 µm, with fine ridges along equatorial zone; in caterpillars of *Autographa gamma* (*Noctuidae*) . *T. inexspectatum*, p. 261

15*. Epispore verrucose or somewhat warty, spore 35-40 µm; rhizoids present; host's body becomes flaccid and darkened after death; in caterpillars of *Cerastis satellitia* (*Noctuidae*) . . . . . *T. dissolvens*, p. 260

16. Epispore aculeolate; spores 38-45 µm, in aphids *T. atrospermum*, p. 256

16*. Epispore almost smooth or otherwise ornamented 17

17. Spore globose to subovoid with the greatest diameter ranging from 28-46 µm 18

17*. Spores spherical, subspherical, or pill-like, of the greatest diameter 36-61 µm 20

18. Epispore rouhgly verruculose or wavy, 3-4 µm thick, spore diameter 35-45 µm; in caterpillars of *Barathra brassicae* (*Noctuidae*). . . . . *T. bereshkoveanum*, p. 257

18*. Epispore smooth, delicately verrucculose or slihghtly shallowed; in beetle larvae 19

19. Spores 28-46 µm, of two-layered epispore 4.5-7 µm thick, smooth or delicately rough; in larvae of *Zabrus gibbosus* (*Carabidae*). . . . . *T. jaczewskii*, p. 262

19*. Spores 28-37 µm in diam., of epispore 1.5-2.5 µm thick, shallowly punctate or delicately rough; in larvae of *Phytonomus* spp. (*Hypera* spp.) (*Curculionidae*) . . . . . *T. punctatum*-complex, p. 269

20. Spores pill-like flattened, dark brown with granulose epispore; in caterpillars of some *Agrotinae* (*Noctuidae*). . . *Zoophthora gammae*, p. 167 subg. *Furia*

20*. Spores spherical or subovoid, not flattened 21

21. Spores cream buff, 41-49 µm, with irregular black warts on the epispore; in *Tipulidae* (*Diptera*) . . . . . *T. porteri*, p. 263

21*. Spores furrowed or ridged; in noctuid caterpillars 22

22. Spores 46-61 µm, with round shallow pits on the epispore; in caterpillars of *Barathra brassicae* (*Noctuidae*) . . . . . *T. pustulatum*, p. 264
22*. Spores spherical, 36-55 µm, with epispore ridged by irregular furrows . . . . . *T. megaspermum*, p. 255

23. Spores small, of the diameter exceptionally exceeding 12 µm 24
23*. Diameter of the smallest spores exceeds 14 µm, usually much greater . 26

24. Spores perfectly transparent with hyaline, almost smooth epispore, globose or broadly ovoid; in *Eremaeus oblongus* deutonymphs . . . . . *T. hyalinum*, p. 261
24*. Spores smoky brownish-grey owing to dark coloured, delicately rough surface of epispore 25

25. Spores 9-12 µm, usually 10.5-11 µm, with wall 1.7-2.3 µm thick of uniformly finely rough surface; number of nuclei unknown in *Pergamasus* sp.; . . . . . *T. pusillum*, p. 264
25*. Spores uninucleate 8-10 µm, usually 8.4-9.2 µm, surrounded with wall 0,5-1,3 µm thick, of the roughness arranged into concentric zones; in *Trichouropoda szczecinensis* . . . . . *T. monokaryoticum*, p. 262

26. Spore diameters range from 14 to about 20 µm., exceptionally single may be greater 27
26*. Spore diameters regularly greater than 20 µm 31

27. Epispore relatively thin, less than 1 µm thick 28
27*. Epispore thicker than 1 µm 29

28. Spore size very uniform, 15.5-16 µm in diam; quite exceptionally 2-3 µm greater; spispore about 0.5 µm thick; in a parasitiform mite . . . . . *T. tatricum*, p. 268
28*. Spore size differentiated from 9-23 µm in diam., epispore about 1 µm thick; in oribatid mite . . . . . *T. tenuiparietatum*, p. 268

29. Spores dark brownish black or smoky black, 16-20 µm, of rugose, warty and spinulose epispore, 3-4 µm thick; in *Pergamasus* sp. . . . . *T. fumosonigrum*, p. 260
29*. Spores hyaline, smooth 30

30. Spores mostly subglobose, 11.4-23 µm, with those of the diam 17-19 µm predominating, single ones ellipsoid or pear-shaped 18-26 x 13-17 µm may occur; in *Trachyuropoda coccinea* . . . . *T. sphaericum*, p. 266
30*. Spores regularly globose of the size little differentiated, 15.5-19 µm, seldom 2-3 µm greater; in different mites of the group *Gamasida* . . . . *T. svalbardense-complex*, p. 267

31. Epispore smooth or nearly so 32
31*. Epispore rough or otherwise ornamented 36

32. Thin superficial layer of epispore fumose or brown give the spores smoky appearnace; spores regularly spherical or subglobose. 33
32*. Spores hyaline or bright yellow, without dark tint of the epispore surface, their shape globose to ellipsoid 34

33. Spores spherical (17-) 21-26 (-28,5) µm, somewhat smoky with epispore 2.5-4 µm thick, delicately rough (seen under high magnification); in *Oplitis alophora* . . . . . *T. oplitidis*, p. 263
33*. Spores globose or subglobose, (32-) 36-38 (-44) µm light golden brown with epispore smooth 6-7.5 µm thick; in *Pergamasus* sp. . . . . *T. distinctum*, p. 260

34. Spores regularly spherical 20-30 µm, exceptionally ovoid or pear-shaped about 30-32 x 22-27 µm, with epispore 5-6 µm thick; in *Trachyuropoda coccinea* . . . . . *T. uropodinis*, p. 269
34*. Spores mostly ovoid to broadly ellipsoid or subglobose, seldom regularly spherical; epispore 1.5-2.5 µm thick 35

35. The greatest diameter of ovoid or ellipsoid spores 21-30 µm, of subglobose ones 23-25 µm; arrangement catenulate; spore content uniformly, thickly granular, bright yellow; in *Pergamasus* sp . . . . . *T. subglobosum*, p. 267
35*. Greatest diameter of the spore ranges between (20-) -30-35 (-40) µm, av. 33.4-3.75; spore content finely granular; arrangement separate; in *Pergamasus brevicornis* . . . . . *T. azygosporicum*, p. 257

36. Epispore uniformly rough, without sinuose or wavy surface in outline 37
36*. Epispore shallowly pitted giving more or less densely sinuose or wavy outline, or with greater flat or depressed areas 39

37. Spores light yellow about 22-23 µm in diam.; epispore 2-3 µm thick, of surface light coloured unevenly asperate; in galumnid mite . . . . . *T. verruculosum*, p. 269
37*. Epispore with distinctly darkened superficial layer, thus appearing fumose 38

38. Spores uniformly spherical, 25-32 µm, content formless; epispore delicately rough; in *Pergamasus* sp. . . . . *T. slovinense*, p. 266
38*. Spores spherical 22-27 µm, and ovoid, 24-29 (-35) x 18-23 (-26.5) µm, of distinctly rough epispore; content evenly granular; in *Veigaia* sp . . . . . *T. silesianum*, p. 265

39. Spores obtuse-multinangular in outline, 22-32 µm, mostly 27-28.5 µm in

diam. with irregular ridges and flat or depressed areas; in *Uropoda minima* . . . . . *T. obtusoangulatum*, p. 263

39*. Spores covered with shallow pits or holes of mildly obtuse borders, giving regularly sinuose appearence of the outline 40

40. Spores mostly 29-35 µm, extremely densely pitted, appearing somewhat rugose punctate on the surface; in different gamasid-mites. . . . . *T. tenuisculpturatum*, p. 268

40*. Spores mostly 33-34 µm, with greater, distinctly separated round holes on the surface; in *Pergamasus* sp . . . . . *T. acaricolum*, p. 256

1. *Tarichium megaspermum* Cohn

Tarichium megaspermum Cohn, Beitr. Biol. Pflanz. 1 (1): 61-71. 1870; — *Empusa megasperma* Brefeld, Bot. Ztg. 35: 352. 1877; — *Entomophthora megasperma* (Cohn) Giard, Bull. Sci. Dep. Nord, Ser. 2, 11: 361. 1879; — *Entomophthora (Tarichium) megasperma* Cohn ex MacLeod et Müller-Kögler, Mycologia 62: 50-51. 1970.

Tarichium sphaerospermum Cohn, Jahresber. Schles. Ges. vaterland. Cultur 47: 87.1870 (nec *T. spherospermum* Cohn, Beitr. Biol. Pflanz. 1 (1): 72. 1870 — see p. 267).

Mycelium at first filamentous, developing tubular hyphae often curved or sinuose or may form straight segments up to 100 µm long, dividing by cross-walls with age and fragmented into subspherical, ovoid or somewhat elongate hyphal bodies, 7-15 µm thick, with the protoplasmic content dense, dark grey. Just before host's death abundant branched hyphal mycelium develops, filling completely its body cavity. Resting spores are formed by swelling of lateral and terminal branches. They are generally spherical, 35-55 (av. 50) µm in diam., with common participation of single less regular in shapes — ovoid, pyriform or even elongate — and larger, up to about 100 x 30 µm. The spores are deep dark brown and completely opaque, with the surface rather deeply irregularly furrowed; both epispore and endospore are dark. Infected caterpillars are at first sluggish but soon lose the ability to move, overcolouring into coal black begininig with anterior part by the presence of numerous, dark hyphal bodies in the integument. Dead mummified larvae are at first distended and soft, with shiny black, moist outer surface, becoming into hard and fragile mummy, usually S-shapely curved.

Distribution and hosts. Europe, North America, in the caterpillars of *Agrotis segetum* (Schiff.) *(Lepidoptera: Noctuidae)*.

Occurrence in Poland. Surroundings of Lublin, Bydgoszcz, Warszawa, Poznań, Szczecin; exact data see Lipa (1963, 1976).

Remarks. General appearance of the vegetative mycelium, development and resting spore formation, show some aspects not typical for *Zygomycetes*, so that Petch (1948: 301) — basing

on the specimens collected in Great Britain and Kenya — has suggested to place this species rather in *Chytridiales*, however he had not done that (Petch 1948: 290). On the other hand Bucher and MacLeod (1974) have confirmed typical for the entomophthorales aspects in the morphology of this fungus on the basis of Canadian specimens, suggesting simultaneously possible connection of this form with the species *Zoophthora virescens* (Thaxter) Batko (reported under the name „*Entomophthora virescens*") found on the same hosts. Two caterpillars of *Agrotis segetum* (Schiff.) from de Thümen's Mycotheca Universalis deposited in the Herbarium of the Warsaw University (WA) labelled „2127. *Tarichium megaspermum* Cohn in Beitr. z. Biologie der Pflanzen I p. 84. Hungaria: Csorvas, in *Agrotis segeti* Hüb. cadaveribus. Oct. 1882. leg. V. Krafft" were reviewed by the author. Any resting spores were lacking, whereas typical elongate hyphal bodies and elements of superficial mycelium occurred abundantly. The conidia — unfortunately the primary intermixed with the secondary ones — represent the shape and size ranges comparable with Keller' s (1992) data concerning „*Erynia virescens*" from Switzerland. A study on this material will be continued. Illustrations given by Lipa (1976) present the way of resting spore formation closer to chlamydospores than azygospores. Regardless of the possible conesquences for the position of *T. megaspermum* in systematics of the fungi as well as for the nomenclature of remaining species counted under this generic name the ontogenesis and adequate arrangement of this fungus should be established on the basis of detailed studies in the future. The fungus is reported as the most common pathogen of some noctuid caterpillars occurring in soil (Petch 1948, Evlakhova 1974, Koval 1974, Lipa 1976).

2. *Tarichium acaricolum* Bałazy et Wiśniewski

Tarichium acaricolum Bałazy et Wiśniewski, Acta Mycol. 20: 163. 1984.

Resting spores light yellow-brownish, regularly globose (27.7-) 33-34 (37.5) µm in diam., with the wall 4.5-5.5 µm thick, of the epispore regularly thickly pitted, wavy in outline. A condensed protoplasm forms a thin, often narrowly semilunar layer around the great, central globule. The resting spores fill the whole host's body cavity together with the basal parts of legs. Other elements of the mycelium unknown.

Distribution and host. Poland, vicinity of Poznań, in a dead mite *Pergamasus* sp. under the Scots pine bark; known only from the type locality.

(3.) *Tarichium atrospermum* (Petch) Bałazy, comb. nov.

Entomophthora (Tarichium) atrosperma Petch, Trans.Brit. Mycol. Soc. 17: 172. 1932 (basionym); — MacLeod et Müller-Kögler, Mycologia 62: 39. 1970.

Resting spores dark brown-black, globose, 38-45 µm in diam., of the epispore covered with stubby, somewhat conical spines up to 2 µm long. Hosts attached to the substrate by few hyaline hyphae resembling rhizoids.

Distribution and host. England, on an unidentified aphid species; known only from the type locality.

4. *Tarichium azygosporicum* Bałazy, Wiśniewski et Kaczmarek

Tarichium azygosporicum Bałazy, Wiśniewski et Kaczmarek; Bull. Pol. Acad. Sci., Biol. Sci. 35: 204-205. 1987.

Hyphal bodies irregularly ovoid or polymorphic, of the dimensions in outline ranging between 30-50 µm, or in form of hyphal segments 25-60 x 4.5-18 µm, filling host's body including basal parts of legs. Resting spores subglobose, when young thinwalled, of the measurements 33.4 ±3.75 x 28.1 ±2.23 µm, when mature — (19.5-) 30-33.6 (-40) x 27.6-30.7 (-38.2) µm (av. 32.1 ±3.79 x 29.1 ±3.73), with walls 1.5-2.5 µm thick of smooth epispore, formed as azygospores by direct budding from the hyphal bodies.

Distribution and host. Central Poland (Holy Cross Mts.), in a female of the mite *Pergamasus brevicornis* Berlese.

(5). *Tarichium bereshkoveanum* Lavrov et Smirnova

Tarichium bereshkoveanum Lavrov et Smirnova in Lavrov, Zametki po faune i flore Sibiri, Tomsk, 16: 65-67. 1949; — *Entomophthora (Tarichium) bereshkoveana* Lavrov et Smirnova in Lavrov ex MacLeod et Müller-Kögler, Mycologia 62: 39-41.1970.

Diseased but still alive insects filled with the hyaline mycelium causing mummification soon after the death. Resting spores spherical to subglobose or suboid, 35-45 µm in diam., surrounded with about 5-7 µm thick walls of dark brown 3-4 µm thick epispore, verruculose or wavy on the surface. Rhizoids unobserved.

Distribution and host. Russia, vicinity of Tomsk, in caterpillars of *Barathra brassicae* L. (*Lepidoptera; Noctuidae*); known only from the type locality.

(6). *Tarichium calliphorae* (Giard) Bałazy, comb. nov.

Entomophthora calliphorae Giard, Bull. Sci. Dep. Nord 11: 356-358. 1879 (basionym); Bull. Sci. France Belgique 20: 205-210. 1889; — *Entomophthora (Tarichium) calliphorae* Giard ex MacLeod et Müller-Kögler, Mycologia 62: 41-42 1970.

Resting spores spherical, about 30 µm in diam., surrounded by about 3-5 µm thick wall of the deep chestnut brown epispore, smooth on the surface. The mature

spores contain a single oil globule surrounded with thin layer of condensed protoplasm; this content become vacuolized after treating with dissolved glycerin. Among the resting spores irregularly elongate, rather thick hyphal bodies have been observed. Host attached to the substratum by numerous rhizoids, probably monohyphal, growing from abdominal segments of affected hosts

Distribution and host. France, vicinity of Wimereux, in *Calliphora vomitoria* var. *dunensis* Giard.

Remarks. Beginning from the Thaxter (1888) monograph the names *Entomophthora calliphorae* and *E. muscivora* Schroeter (1886) have generally been treated as synonymous (Lakon 1919, Batko 1964, Gustafsson 1965, MacLeod & Müller-Kögler 1970). However, Schroeter (1886: 223) has marked only a prudent supposition about a possible identity of *E. muscivora* with Giard's species, whereas Giard (1889: 206) treated these species as allied ones („voisine"). Petch (1948: 288) has used Schroeter's name while determining English materials from flies. In the light of hitherto stated differentiation of the entomophthoralean forms infecting adult flies, as well as in the face of numerous ambiguities introduced to references as results of endeavours to connect some resting spore stages with anamorphs of these fungi occurring on different host individuals, the author of the present review is of the opinion that the bases for the synonymization of the two considered here names are too weak. Beside the unidentified hosts in the case of Schroeter's material there are considerable differences in the resting spore dimenensions and in habitat conditions (dry, sandy environments in France and generally more fertile and of considerably higher humidity in Silesia). It is an authors's feelling, based on a rather large experience, that these characteristics may constitute essential features for the species differentiation. For this reason the nomenclatural combinations deriving from Batko's (1964, 1966) arrangement have not been considered here as synonyms, although their correctness has not been exluded.

(7). *Tarichium cimbicis* (Bubàk) Lakon

Tarichium cimbicis (Bubàk) Lakon, Z. angew. Entomol. 5: 182. 1919; — *Entomophthora cimbicis* Bubàk, Ann. Mycol. (Berlin) 4: 105-106. 1906; — *Entomophthora (Tarichium) cimbicis* Bubàk ex MacLeod et Müller-Kögler, Mycologia 62: 43. 1970.

Resting spores filling host's inside spherical or broadly ellipsoid, 26-48 x 24-32 µm, yellowish, surrounded by the wall 1-1.5 µm thick of sligtly verruculose surface.

Distribution and host. Bohemia, in pupae of *Cimbex* sp.; known only from the type locality.

Remark. Petch's (1944) suggestion about the possible synonymy of *T. cimbicis* and *Entomophaga tenthredinis* (under the name „*Entomophthora tenthredinis*") cannot be accepted (see also MacLeod and Müller-Kögler, 1970: 43 and discussion in this review concernig *E. tenthredinis* — p. 126).

(8). *Tarichium cleoni* (Wize) Lakon

Tarichium cleoni (Wize) Lakon, Z. Pflanzenkrkh. 25: 262. 1915; Z. angew. Entomol. 5: 182. 1919; — *Massospora cleoni* Wize, Bull. Intern. Acad. Sci. Cracovie, Cl. Sci. Math.-Naturwiss. (1904): 716-717. 1905; — *Entomophthora (Tarichium) cleoni* (Wize) Bubàk ex MacLeod et Müller-Kögler, Mycologia 62: 44. 1970.

Mycelium filling diseased insects consists of hyaline hyphae 12-15 µm thick, divided by cross-walls on 40-60 µm long segments. Resting spores, probably azygospores, orange in mass, spherical, 25-30 µm in diam., with thick epispore covered by aculeolate, spine-like outgrowths 3-5 µm long.

Distribution and host. Ukraine, in larvae and pupae of *Bothynoderes punctiventris* (Germar) (*Coleoptera: Curculionidae*) in soil; known only from the type locality.

(9). *Tarichium coleopterorum* (Petch) Bałazy, comb.nov.

Entomophthora (Tarichium) coleopterorum Petch, Trans. Brit. Mycol. Soc. 17: 172. 1932; MacLeod et Müller-Kögler, Mycologia, 62: 44-45. 1970 (p.p.).

Resting spores filling host's inside spherical, 35-50 µm in diam. to broadly ovoid 48-52 x 44-46 µm or somewhat pyriform, about 56 x 44 µm, covered with dark brown wall up to 6 µm thick, of densely verrucose surface. Host attached to the substratum by compact fascicles of rhizoids emerging from its abdomen.

Distribution and host. England, in unidentified beetles (*Coleoptera*).

Remarks. The considerations concerning synonymy of this species — see *Zoophthora* subg. *Zoophthora larvivora* Bałazy, (p. 236 in this review). The character of rhizoids indicates, however, possible affiliation of this species to the genus *Zoophthora* subg. *Zoophthora*.

(10). *Tarichium cyrtoneurae* (Giard) Bałazy, comb. nov.

Entomophthora cyrtoneurae Giard, Bull. Sci. France Belgique, 19: 301. 1888; — *Entomophthora (Tarichium) cyrtoneurae* Giard ex MacLeod et Müller-Kögler, Mycologia 62: 45. 1970.

Resting spores filling host's inside globose, 14-20 µm. Host attached to substratum probably by rhizoids.

Distribution and host. France, in adult specimens of *Cyrtoneura hortorum* Meigen (*Diptera: Muscidae*); known only from the type record on the basis of incomplete description.

(11). *Tarichium dissolvens* (Vosseler) Lakon

Tarichium dissolvens (Vosseler) Lakon, Z. Pflanzenkrankh. 25:262. 1915; — Z. angew. Entomol. 5: 182. 1919; — *Entomophthora dissolvens* Vosseler, Jahresber. Ver. vaterland. Naturk. Würtenberg 58: 386-388. 1902; — *Entomophthora (Tarichium) dissolvens* Vosseler ex MacLeod et Müller-Kögler, Mycologia 62: 45-46. 1970.

Resting spores spherical 35-40 µm in diam when mature, surrounded by 2-layered wall about 2 µm thick, verrucose or warty on the surface, often with two bristle like appendices remaining from the peculiar cell connecting resting spore with maternal hyphae. The resting spores were formed laterally on short stalks on the hyphae, hyaline when young. Dead caterpillars flaccid, filled with dark brown, granular fluid containing numerous resting spores. Host affixed to the substratum by rhizoids.

Distribution and host. Germany, in a night-moth caterpillar, probably *Cerastis satellitia* (L.) (*Lepidoptera*: *Noctuidae*); known only from the type locality.

12. *Tarichium distinctum* Bałazy, Wiśniewski et Kaczmarek

Tarichium distinctum Bałazy, Wiśniewski et Kaczmarek, Bull. Acad. Pol. Sci. Biol. Sci., 35: 205-206. 1987.

Resting spores light golden brown in mass, subglobose, (32-) 36.5-38 (-44) µm in diam., or single widely ellipsoid 32-44.5 x 25-39 µm, surrounded by walls 6.2-7.5 µm thick, with slightly marked single or double stratification; the superficial layer about 1.5-2 µm thick with the surface brownish, smooth. The content of the spores formless, sometimes with fine, uneven granulation.

Distribution and host. North-Eastern Poland (Białowieża), in the mite *Pergamasus* sp.

13. *Tarichium fumosonigrum* Bałazy et Wiśniewski

Tarichium fumosonigrum Bałazy et Wiśniewski, Acta Mycol. 20: 163-164. 1984.

Resting spores dark brown to smoky-black, completely opaque, regularly globose (16.3-) 17.7-18.1 (-19.9) µm, with walls 3-4 µm thick of epispore rugose, warty or in some parts spinulose. Their content is formless, undifferentiated or thickly granular. The spores fill the posterior half of host's body. Vegetative structures unobserved.

Distribution and host. Poland (vicinity of Poznań), in a dead mite *Pergamasus* sp.

(14). *Tarichium inexspectatum* Jaczewskii

Tarichium inexspectatum Jaczewskii in Jaczewskii A. A. et Jaczewskii P. A., Opredelited gribov, 1: 225. Moskva-Leningrad. 1931; — *Entomophthora (Tarichium) inexspectata* Jaczewskii in Jaczewskii A. A. et Jaczewskii P. A. ex MacLeod et Müller-Kögler, Mycologia 62: 47-48. 1970.

Mycelium inside host's body at first filamentous, breaking with age into hyphal body like segments, which produce intercalary chlamydospores. The latter are at first hyaline, darkening gradually and becoming dark brown when mature. They are spherical, 41-48 µm, or somewhat pear-shaped. The chlamydospores show two fine ridges along the equatorial zone, caused by hyphal residue.

Distribution and host. Former Soviet Union, in caterpillars of *Autographa gamma* (L.) (*Lep.*: *Noctuidae*).

15. *Tarichium hyalinum* Bałazy, Wiśniewski et Kaczmarek

Tarichium hyalinum Bałazy, Wiśniewski et Kaczmarek, Bull. Pol. Acad. Sci., Biol. Sci. 35: 206-207. 1987.

Resting spores hyaline, globose (6.1-) 8.7-9.6 (-12.4) µm, or ovoid (7.2-) 9.2-10.4 (-12.7) x (6.2-) 7.3-8.4 (-10.9) µm, surrounded by walls 0.4-2 µm thick, finely rough on the surface. The inside of the spore is filled with a relatively big fat globule, 5-6 x 3-5 µm, surrounded by about 2 µm thick plasmatic layer usually semilunar in outline of the optical section. Inside the gnathosoma and in articles of legs single smaller resting spores were observed.

Distribution and host. Central Poland (Włocławek), in a deutonymph of the mite *Tectocepheus velatus* (Michael).

(16). *Tarichium jaapianum* (Bubàk) Bałazy, comb. nov.

Entomophthora (Tarichium) jaapiana Bubàk, Ann. Mycol. Berlin, 14: 341. 1916 (basionym); — MacLeod et Müller-Kögler, Mycologia 62: 48. 1970.

Mycelium inside host's body filamentous, of the hyphae frequently branched, 10-14 µm thick, with the lower portions strongly convoluted and the upper portions giving rise to clavate, continuous spore bearing structures. Resting spores globose, 35-45 µm, with walls smooth 2-2.5 µm thick, hyaline or light yellow. Some of the resting spores that emerged at the joints or between appendages appeared in a linear arrangement.

Distribution and host. Germany (Thuringerwald), in the leaf-hopper *Euacanthus interruptus* L. (*Homoptera: Cicadellidae*).

(17). *Tarichium jaczewskii* Zaprometov

Tarichium jaczewskii Zaprometov, Materialy po flore gribov Centralnoj Azii, Taschkent 2: 6, 1928; — *Entomophthora (Tarichium) jaczewskii* Zaprometov ex MacLeod et Müller-Kögler, Mycologia 62: 48-49. 1970.

Resting spores, reported as azygo- and zygospores, spherical, 28-46 µm in diam., with almost smooth or verruculose epispore 4.5-7 µm thick, dark brown in color. The infected larvae become black, mummified.

Distribution and host. Central Asia, (formerly Soviet Union, Samarkand and Katta-Kurgan), in larvae of *Zabrus gibbosus* (Goeze) (*Coleoptera: Carabidae*).

Remark. Possible synonymy with *Zoophthora zabri* (Rozsypal ex Ben-Ze' ev et Kenneth) Humber has been discussed by Batko (1964e) and Ben-Ze' ev and Kenneth (1982).

(18). *Tarichium lavrovium* Gukasjan

Tarichium lavrovium Gukasjan, Mikroorganizmy v borbe c vrediteljami lesa, Moskva: 202-203. 1966; — *Entomophthora (Tarichium) lavrovia* Gukasjan ex MacLeod et Müller-Kögler, Mycologia 62: 49-50. 1970.

Resting spores globose or broadly ellipsoid, 36-40 µm in diam., with epispore about 2.5 µm thick of unevenly striate epispore, brownish-green in colour.

Distribution and host. Asia (Siberia), in caterpillars of *Eurois occulta* L. (*Lepidoptera: Noctuidae*).

19. *Tarichium monokaryoticum* Bałazy, Wiśniewski et Kaczmarek

Tarichium monokaryoticum Bałazy, Wiśniewski et Kaczmarek, Bull. Pol. Acad. Sci., Biol. Sci. 35: 207-208. 1987.

Resting spores globose, (8-) 8.4-9.2 (-10.2) µm, exceptionally in the articles of legs ovoid, ca 9.6 x 7.5 µm., containing one centrally located nucleus of the diam. 2.3-3 µm, surrounded with finely granular plasmatic content. The walls are 0.5-1.3 µm thick with thin brownish layer of the exospore rough on the surface; in optical sections this roughness shows rather distinct concertric arrangement. Hyphal fragments 4.5-5.5 µm thick, without any content and with sparse cross-walls occurred in the host integument.

Distribution and host. The fungus was found in a dead female of the mite *Trichouropoda szczecinensis* Wiśniewski et Hirschmann from subcortical detritus of raw wood imported to Poland from the Republic of Central Africa and stored in Bralinek Factory of Timber Processing. Because of the short time of the storage of this material in Poland the fungus seems to be rather of Afican origin.

20. *Tarichium obtusoangulatum* Bałazy et Wiśniewski

Tarichium obtusoangulatum Bałazy et Wiśniewski, Acta Mycol. 20: 164. 1984.

Resting spores irregularly circular or obtuse multiangular in outline, (22-) 27-28.5 (-32) μm in diam.; the walls 3.2-3.5 μm thick, of the epispore thickly rumpled with obtuse, broadly conical convexities. Their content formless, transparent.

Distribution and host. Western Poland (Krosno Odrzańskie) in a dead mite *Uropoda minima* Kramer.

Remark. The form of the resting spores resemble young zygospores of *Basidiobolus ranarum*.

21. *Tarichium oplitidis* Bałazy et Wiśniewski, n. sp.

Diagnosis. *Sporae perdurantes globosae, (16.5-) 21-26 (-28.5) μm, hyalinae vel paulum fumosae. Membrana 2.5-4 μm crassa, cum tenere aspero, clarobrunneo episporio. In deutonympha acarorum Oplitis allophora et in femina Trichouropoda ovalis parasitans.*

Holotypus. *Specimen numero 2225 in collectione* ZBS PAN *designatum, in Oplitis alophora, die 22 mensis Maii anno 1988, Posnaniae collectum.*

Resting spores regularly globose, (16.5-) 21-26 (-28.5) μm in diam., almost hyaline or slightly fumose, surrounded by walls 2.5-4 μm thick, with delicately rough, light brownish epispore. Their inside contents one relatively big, subglobose oil drop surrounded with narrow, semilunar layer of condensed protoplasm.

Distribution and host. Poland (Poznań), in a deutonymph of the mite *Oplitis alophora* (Berlese) and a female of *Trichouropoda ovalis* Koch.

Etymology: *Oplitis* — generic name of noe the host mites.

(22). *Tarichium porteri* (Soper) Bałazy, n. comb.

Entomophthora porteri Soper, Mycotaxon 1: 26. 1974 (basionym); — *Massospora tipulae* Porter, J. Elisha Mitchell Sci. Soc. 58: 65-67. 1942; — *Entomophthora (Tarichium) tipulae*

Porter ex MacLeod et Müller-Kögler, Mycologia 62: 54. 1970 (nec *Entomophthora tipulae* Fres., Abh. Senckenberg. naturforsch. Gesellsch. 2 (2): 201. 1858).

Hyphal bodies filling host's body cavity colourless, of irregular shapes, usually one-celled. Resting spores black in mass fill abdominal part of the insect body. They are spherical or subsphaerical, 36-45 (ca. 39) µm in diam., surrounded by walls with dark finger-like projections or warts on the surface. Hyphal bodies usually elongate but of rather various shapes, 90-116 x 19.5-32 µm, colourless. The remainings of hyphal bodies are often attached to the resting spores as cup-like appendages at the foramen.

Distribution and host. North America (USA, Tennessee), in an adult of *Tipula triplex colei* Alexander (*Diptera: Tipulidae*).

Remarks. Because of possible misinterpretations of the names *Entomophthora tipulae* Fres., 1858 and *Entomophthora (Tarichium) tipulae* Porter ex MacLeod et Müller-Kögler, 1970, in face of unknown conidial sporulation of the latter it should be justified to accept the nomenlatural change proposed by Soper (1974). The fungus reported by Petch (1932, 1948) under the names *Entomophthora tipulae* and *Empusa tipulae* cannot be identified either as *Entomophaga tipulae* (Fres.) Humber, or *Tarichium porteri* (Soper) Bałazy.

23. *Tarichium pusillum* Bałazy et Wiśniewski

Tarichium pusillum Bałazy et Wiśniewski, Acta Mycol. 20: 164-165. 1984.

Resting spores globose or subglobose (9-) 10.5-11 (-12) µm, with grey-yellow walls 1.7-2.3 µm thick of finely rough, brownish epispore, fill the host's body cavity together with basal parts of legs. Their content roughly grained and irregularly vacuolized.

Distribution and host. Poland (vicinity of Poznań), in a dead specimen of the mite *Pergamasus* sp.

(24.) *Tarichium pustulatum* Weiser

Tarichium pustulatum Weiser, Česka Mykol. 19: 203. 1965; — *Entomophthora (Tarichium) pustulata* Weiser ex MacLeod et Müller-Kögler, Mycologia 62: 53. 1970.

Resting spores dark brown, spherical, 46-61 µm in diam. (cv. 50 µm), covered by 4-5 µm thick wall with irregular pits about 1 µm deep and 10-15 µm broad on the epispore. A round foramen 11-12 µm broad with short collar is present on every spore.

Distribution and host. Bohemia (near Hradec Kralove), in caterpillars of *Barathra brassicae* L. (*Lepidoptera: Noctuidae*).

25. *Tarichium rhagonycharum* Bałazy

Tarichium rhagonycharum Bałazy, Bull. Acad. Pol. Sci., Ser. Sci. Biol., 29(1981): 223-224. 1982.

Dead insects filled with tangled and moderately branched hyphae (9-) 14-25 µm thick with sparse septa, often fragmented into particular segments over 100 µm long. Numerous spherical or slightly ovoid resting spores of the diameter 43-55 (-62) µm or 61-68 x 45-56 µm, with walls 2.5-3 µm thick, of hazel brown smooth epispore, are formed laterally and terminally by budding from the hyphae. Rhizoids in compact pseudorhizomorphs growing as 2-3 bundles from thoracical and abdominal parts of the host body underside.

Distribution and host. Poland (Wielkopolski National Park), Denmark and Switzerland in adult beetles of *Rhagonycha lignosa* Müll. and *R. fulva* Scop. (*Coleoptera: Cantharidae*).

Remark. On the basis of the rhizoid morphology it is unobtedly a representative of the genus *Zoophthora* subgenus *Zoophthora*, however conidial sporulation has never been found.

26. *Tarichium silesianum* Bałazy et Wiśniewski, n. sp.

Diagnosis. *Sporae perdurantes globosae, in diametrum (21-) 22-27 (-30) µm, vel late ellipsoidales, dimensionibus (23.5-) 24-29 (-35) x (18-) 19-23.5 (-26.5) µm, raro piriformes, plasmatae parvigranulosa continentes, quae hospitis corpus et extremitates implent. Membrana 2.5-3 µm crassa, cum brunneo episporio, plane, sed tenere aspero. In femina acarorum Veigaia sp. parasitans.*

Holotypus. *Specimen numero 2222 in collectione ZBS PAN designatum, die 23 mensis Februarii anno 1989, in silva conifera prope* Wałbrzych *(Silesia), ad Ipidis typographi sub cortice Piceae abietis collectum* (leg. R. Wojtowicz).

Resting spores filling host's body cavity together and its legs very numerous, spherical, (21-) 22-27 (30) µm, and broadly ellipsoid or somewhat pear-shaped, (23.4-) 24-29 (-35) x (18-) 19-23.5 (-26.5) µm, with walls 2.5-3 µm thick of the brown epispore, distinctly, although not strongly rough. Their content finely granular of the grains 1-1.5 µm thick.

Distribution and host. South-Western Poland (Wałbrzych), in a female of the mite *Veigaia* sp. under bark of Norway spruce (*Ips typographus* L. feeding site).

Etymology: *Silesia* — Latin name of the region of Poland, where the fungus was found.

27. *Tarichium sloviniense* Bałazy et Wiśniewski, n. sp.

Diagnosis. *Sporae perdurantes globosae diametro (25-) 26-30 (-32) µm. Membrana 2,5-3 µm crassa cum tenui episporio fusco, tenere, sed irregulariter aspero. Fungus hospitis idiosoma implet, in extremitatibus non invenitur. In femina acarorum Pergamasus sp. parasitans.*

Holotypus. *Specimen numero 2220 in collectione* ZBS PAN *designatum, Februarii 1 Julii mensis anno 1988 sub cortice Pini silvestris in silva conifera in Sloviniensi Horto Nationali (Polonia septentrionalis) collectum* (leg. J. Wleklinska).

Resting spores regularly globose of rather constant size (25-) 26-30 (-32) µm, with walls 2.5-3 µm thick thin; dark brown epispore delicately and irregularly rough on the surface. Their content indistinctly differentiated on central globule and semilunar, surrounding protoplasmic layer. The spores scattered in different numbers in host's idiosoma, not coming into legs.

Distribution and host. Northern Poland, Baltic seaside, in the Słowiński National Park, in a female of the mite *Pergamasus* sp. under bark of Scots pine log.

28. *Tarichium sphaericum* Bałazy et Wiśniewski

Tarichium sphaericum Bałazy et Wiśniewski, Acta Mycol. 20: 165-166. 1984.

Resting spores smooth, colourless, globose (11.5-) 17-19 (23) µm, seldom ellipsoid or pyriform 18-26 x 12.7-17 µm, with walls 1.5-3 µm thick, fill the host integument not coming into legs. They contain usually a central globule surrounded by thin, formless protoplasmic layer.

Distribution and host. Poland (vicinity of Poznań), in a dead specimen of the mite *Trachyuropoda coccinea* (Michael).

29. *Tarichium sphaerospermum*-complex

Resting spores globose of the diameter ranging between (19-) 20-25 (-28) µm, with hyaline or light yellow walls 2,5-3,5 µm thick of smooth epispore. Rhizoids usually present — in typical pseudorhizomorphs.

Distribution and hosts. Possible to find elsewhere and on different arthropod species.

Occurrence in Poland. Białowieża National Park, in an adult of braconid hymenopteran (leg. A. Batko) and in a pentatomid bug (leg. S. Bałazy), Wielkopolski National Park, in a plant hopper (leg. S. Bałazy).

Remarks. Above characteristic corresponds with the resting spore stages of a number of species related to *Zoophthora* subg. *Zooophthora radicans* (Brefeld) Batko, mostly identified in the past as „*Entomophthora sphaerosperma*", which are, however, distinguishable on the basis of exact conidial biometrics and peculiarities in the shape of the capilliconidia. Moreover, these differences are usually correlated with the pathogenicity to closely determined hosts (see p. 202). For the practical reasons the name *Tarichium spherospermum*-complex may be conditionally allowed to use instead of a descriptive information, but only in cases when there is not obvious connection of considered fungus resting spores with any conidial sporulation, at least until additional criteria for the differentiation are determined.

30. *Tarichium subglobosum* Bałazy et Wiśniewski

Tarichium subglobosum Bałazy et Wiśniewski, Acta Mycol. 20: 166. 1984.

Resting spores globose, (18-) 23.5-25.5 (-33) µm, ovoid, broadly ellipsoid or somewhat pyriform, 21-31 x 17-25 µm, often with a small convexity in one side, surrounded by walls 2-2.5 µm thick, light brownish-yellow, of smooth or finely rough epispore. Their content yellowish, granular. The spores occur both in the body cavity and in legs.

Distribution and hosts. Poland (vicinity of Poznań), in a dead specimen of the mite *Pergamasus* sp.

31. *Tarichium subpunctulatum* Bałazy

Tarichium subpunctulatum Bałazy, Bull. Acad. Pol. Sci., Ser. Sci. Biol., 29 (1981): 224-225. 1982.

Resting spores globose, 25-35 µm, hyaline, with epispore up to 3 µm thick, covered by regular shallow pits on the surface, appearing delicately punctate. Rhizoids monohyphal without specialized holdfasts.

Distribution and host. Poland (Wielkopolski National Park), in an adult of the brachycerous fly in a moist forest habitat. The character of rhizoids and habitat conditions suggest this fungus to belong to the genus *Zoophthora* subg. *Erynia*.

32. *Tarichium svalbardense*-complex

Resting spores filling host's body cavity regularly globose, (14.5-) 17-20 (-23.2) µm, colouress, surrounded by the walls 2-4 µm thick of smooth epispore. Their content is usually unevenly granular.

Distribution and hosts. Northern and Central Europe, in several species of mites mostly of the group *Parasitiformes*, from different habitats.

Occurrence in Poland. Poznań and surrounding, Czersk, Bieszczady Mts., in *Veigaia* sp., *Pergamasus* sp., *Dinychus carinatus* Berlese and an unidentified oribatid mite.

Remarks. The majority of samples correspond with typical features of *T. svalbardense* (Thor) Bałazy et Wiśniewski (1978) [basionym: *Rhagidiasporidium svalbardense* Thor, Z. Parasitenkde 2: 554-555. 1930; — *Entomophthora* (?) *svalbardense* (Thor) Weiser et Daniel, Fol. Parasitol. (Praha) 16: 275-278. 1969]. However, single specimens show somewhat greater range of the resting spore size variability. Unfortunately, there is rather difficult to obtain longer series of specimens of the same origin to study real variability range, so at present the recommended practice seems to be rather gathering materials treated by prudency as a complex species.

33. *Tarichium tatricum* Bałazy et Wiśniewski

Tarichium tatricum Bałazy et Wiśniewski, Acta Mycol. 20: 1984.

Hyphal bodies subglobose, 15.5-18.7 x 15.5-16.5 µm occurring in the host's idiosoma in catenulate arrangement. Resting spores regularly globose (14.1-) 15.5-16 (-20) µm, transparent, with finely granular content, surrounded by walls about 0.5 µm thick, smooth.

Distribution and host. Southern Poland (Tatra Mts. National Park), in a dead deutonymph of a mite from the suborder *Parasitiformes*.

34. *Tarichium tenuiparietatum* Bałazy et Wiśniewski

Tarichium tenuiparietatum Bałazy et Wiśniewski, Acta Mycol. 20: 167. 1984.

Resting spores globose of strongly differentiated dimensions — (9-) 14-16 (-23.5) µm, with the content formless, transparent, surrounded by the walls 0,5-1 µm thick, smooth.

Distribution and host. Poland (vicinity of Poznań), in a dead oribatid mite.

35. *Tarichium tenuisculpturatum* Bałazy et Wiśniewski

Tarichium tenuisculpturatum Bałazy et Wiśniewski, Acta mycol. 20: 168. 1984.

Resting spores filling host's body cavity icluding gnathosoma and basal articles of legs globose, (23-) 29.5-31.7 (-37.4) µm, with formless, transparent content,

light yellow to golden yellow in mass. The walls 3.5-3.9 μm thick, of the epispore with moderately dense pitts giving the appearence of fine rugosity.

Distribution and hosts. Poland (vicinity of Poznań), very common species in dead mites of the genera *Veigaia* and *Pergamasus*, found also in a female of *Eviphis ostrinus* (C. L. Koch). Mostly in forest litter and subcortical detritus.

(36.) *Tarichium uropodinis* Bałazy et Wiśniewski

Tarichium uropodinis Bałazy et Wiśniewski, Bull. Acad. Pol. Sci., Ser. Sci. Biol. 30: 81. 1982.

Resting spores hyaline, regularly globose of the diam. 19.8-30 μm, seldom ovoid or pear-shaped 31-32 x 22-26.5 μm, with walls 5-6.2 μm thick of smooth epispore. Their content formless or finely granular. Single — probably unripe — resting spores were somewhat greater — 32-33 μm in diam, of thinner walls — 2.2-3.7 μm.

Distribution and host. Germany (Darmstadt), in a female of the mite *Trachyuropoda coccinea* (Michael).

37. *Tarichium verruculosum* Bałazy, Wiśniewski et Kaczmarek

Tarichium verruculosum Bałazy, Wiśniewski et Kaczmarek, Bull. Pol. Acad. Sci., Biol. Sci. 35: 209-210. 1987.

Resting spores light yellow-brownish in mass, globose, (19.5-) 22-23 (-29), seldom ellipsoid, 21-26 x (15.6-) 18.7-22 μm, surrounded by the walls 2-3 μm thick with delicate warts, sometimes having acute tips, scattered all over the epispore, forming irregularly rounded fields remarkable in microscopical view.

Distribution and host. Central Poland (Kłodawa), in a dead mite of the family *Galuminidae* from the sea eagle *Heliaeetus albicilla* nest.

38. *Tarichium punctatum*-complex

Hyphal bodies and hyphae filling host's body 4-7 (7.5) μm thick, densely interwoven. Resting spores smoky to blackish 25-37.5 μm in diam,; the wall about 2-3 μm thick, of minute, dense but irregular punctation on the surface. Infected host's larvae at first weakly mummmified, becoming black, hard and fragile when dried, but often dissolve under natural conditions or in damp chambers. Rhizoids in pseudorhizomorphs or absent.

Distribution and hosts. Europe, North America, Asia, in larvae and pupae of *Phytonomus* spp. (*Hypera* spp.), mostly in alfalfa fields.

Occurrence in Poland. Lubin near Mogilno – type locality of Garbowski's (1927) record.

Remarks. The range of species producing resting spores of similar characteristics has been discussed by Ben-Ze'ev and Kenneth (1980). Garbowski's (1927) original but brief description of „*Entomophthora (Tarichium) punctata* sp. n." was based on visually heterogenous material from *Phytonomus variabilis* Hrbst. on alfalfa, obtained in dried state. He treated particular series of variously coloured mummies as successive development phases of one pathogenic fungus species, whereas Ben-Ze'ev and Kenneth (1980) stated simultaneous occurrence of at least two species forming resting spores of similar characteristics (*Conidiobolus osmodes* and a species of *Zoophthora*). According to the author's observations on *Zoophthora phytonomi*, this fungus produces smoky or dark coloured, verruculose resting spores when infected host's larvae are transferred to laboratory rearing in early phases of mummification (see p. 246). Hence, the transcolouring intensity of the resting spore wall need not be obligatorily treated as a criterion for species separation, and the affiliation to the family *Ancylistaceae* or *Entomophthoraceae* may easily be determined by karyology.

REFERENCES

Abrahamson L. P., Harper D. 1973. Microbial insecticides control forest tent caterpillar in South-Western Alabama. U. S. Forest Serv., Res. Note: 80-157.

Alexopoulos C. J. 1966. Einführung in die Mycologie. Jena and Stuttgart.

Amin E. N. E., Webster J. 1980. British records. Trans Brit. Mycol. Soc. 74: 633-635.

Aruta C. M., Carrillo R. L. 1989. Identifica-cion de hongos del orden *Entomophthorales* en Chile. III. Agro sur 17(1): 10-18.

Arx J. A., V. 1974. The genera of fungi sporulating in pure culture. Verlag von J. Cramer. Vaduz.

Bałazy S. 1978. A new species of *Entomophthoraceae* (*Mycophyta*: *Entomophthorales*) from Poland. J. Invertebr. Pathol. 31: 275-279.

Bałazy S. 1982a. New species of *Entomophthoraceae* from the Wielkopolski National Park. Bull. Acad. Pol. Sci. Ser. Sci. Biol. 29: 221-226.

Balazy S. 1982.b Entomophthoraceous fungi on parasitic *Hymenoptera* Bull. Acad. Pol. Sci., Ser. Sci. Biol. 29: 227-230.

Bałazy S. 1984 a. On rhizoids of *Entomophthora muscae* (Cohn) Fresenius *Entomophthorales*: *Entomophthoraceae*). Mycotaxon 19: 397-407.

Bałazy S. 1984b. Taksonomija entomopathogennych gribov i voprosy ich primenenija w zaszczite rastenii i chraneni. Sborn. dokl. po teme RRS-12 w: Izuczenie entomopatogennych organizmov, razrabotka technologii proizvodstwa i primenenija. Rytro — Poznań: 141-157.

Bałazy S. 1986. Taxonomic criteria for inter and intraspecific differention in the entomophthoraceae exemplified by the subgenus *Zoophthora*. In: Fundamental and applied aspectes of invertebrate pathology. Eds. R. A. Samson, J. M. Vlak, D. Peters. Wageningen: 201-204.

Bałazy S., Miętkiewski R., Majchrowicz I. 1990. Mikozy mszyc — ich znaczenie i perspektywy wykorzystania w ochronie roślin. Zesz. Probl. Post. Nauk Roln. 392: 35-56.

Bałazy S., Sokołowski A. 1977. Morphology and biology of *Entomophthora myrmecophaga*. Trans. Br. Mycol. Soc. 68: 134-137.

Bałazy S., Wiśniewski J. 1978. Nowy dla Polski gatunek owadomorka (*Mycophyta*, *Entomophthoraceae*) z roztocza *Veigaia* sp. Pozn. Tow. Przyj. Nauk, Prace Kom. Nauk. Roln. Lesn. 46: 36.

Bałazy S., Wiśniewski J. 1982 Two species of entomopathogenic fungi on the myrmecophilic mite *Trachyuropoda caccinea* (Michael, 1891) (*Acari*: *Uropodine*). Bull. Acad. Pol. Sci. 30: 81-84.

Bałazy S., Wiśniewski J. 1984. Records on some lower fungi occurring in mites (*Acarina*) from Poland. Acta Mycol. 20: 159-172.

Bałazy S., Wisniewski J. 1986. Two new species of *Hirsutella* infecting mites in Poland. Trans. Brit. Mycol. Soc. 86: 629-635.

Bałazy S., Wiśniewski J., Kaczmarek S. 1987. Some noteworthy fungi occurring on mites. Bull. Acad. Pol. Sci., Ser. Sci. Biol. 35: 199-224.

Batko A. 1964a. Notes on entomophthoraceous fungi in Poland. Entomophaga, Mem. Hors., Ser. 2: 129-131.

Batko A. 1964b. Remarks on the genus *Entomophthora* Fresenius 1856 non Nowakowski 1883 (*Phycomycetes*: *Entomophthoraceae*) Bull. Acad. Pol. Sci., Ser. Sci. Biol., 12 (9): 319-321.

Batko A. 1964 c. On the new genera: *Zoophthora* gen. nov., *Triplosporium* (Thaxter) gen.nov. and *Entomophaga* gen.nov. (*Phycomycetes*: *Entomophthoraceae*). Bull. Acad. Pol. Sci., Ser. Sci. Biol. 12: 323-326.

Batko A. 1964 d. Remarks on the genus *Lamia* Nowakowski 1883 *Culicicola* Nieuwland 1916 (*Phycomycetes*: *Entomophthoraceae*) Bull. Acad Pol. Sci., Ser. Sci. Biol. 12: 399-403.

Batko A. 1964 e. Some new combinations in the fungus family *Entomophthoraceae* (*Phycomycetes*). Bull. Acad. Polon. Sci., Ser. Sci. Biol. 12: 403-406.

Batko A. 1966 a. A new aphidicolous fungus from Poland, *Zoophthora phalloides* sp. nov. (*Entomophthoraceae*). Acta Mycol. 2: 7-13.

Batko A. 1966 b. On the subgenera of the fungus genus *Zoophthora* Batko 1964 (*Entomophthoraceae*). Acta. Mycol. 2: 15-21.

Batko A. 1974a. Filogeneza a struktury taksonomiczne *Entomophthoraceae* In: Ewolucja Biolo-

giczna, Szkice teoretyczne i metodologiczne. Ed. C. Nowiński. Wrocław — Warszawa — Kraków — Gdańsk (in Polish, Engl. summ.).
Batko A. 1974b. Zarys hydromikologii. PWN. Warszawa.
Batko A., Kmitowa K., 1962. Zmienność morfologiczna *Empusa muscae* Cohn, jako przyczynek do badań nad strukturą gatunku u grzybów owadobójczych. Zesz. Probl. Post. Nauk Roln. 35: 249-254.
Batko A., Weiser J. 1965. On the taxonomic postition of the fungus discovered by Strong, Wells and Apple: *Strongwellsea castrans* gen. et sp. nov. (*Phycomycetes*: *Entomophthoraceae*). J. Invertebr. Pathol. 7: 455-463.
Benjamin R. K. 1962. A new *Basidiobolus* that forms microspores. Aliso 5: 223-233.
Ben-Ze' ev I. 1982. *Erynia neopyralidarum* sp. nov. and *Conidiobolus apiculatus*, pathogens of pyralid moths components of misdescribed species *Entomophthora pyralidarum* (*Zygomycetes*: *Entomophthorales*). Mycotaxon 26: 273-292.
Ben-Ze' ev I. 1986a. New *Erynia* species found in T. Petch's collection. In: Fundamental and applied aspects of invertebrate pathology. Eds. R. A. Samson, J. M. Vlak, D. Peters. Wageningen: 219.
Ben-Ze' ev I. 1986 b. Notes on *Entomophthorales* (*Zygomycotina*) collected by T. Petch: II. *Erynia ellisiana* sp. nov., non *Erynia forficulae* (Giard), comb. nov., pathogens of *Forficulidae* (*Dermaptera*). Mycotaxon 27: 263-269.
Ben-Ze' ev I. 1987. Notes on *Entomophthorales* (*Zygomycotina*) collected by T. Petch: III. *Erynia suturalis* sp. nov. and other *Erynia* species recorded on *Coleoptera*. Mycotaxon 28: 403-412.
Ben-Ze' ev I., Keller S., Ewen A. B. 1985. *Entomophthora erupta* and *Entomophthora helvetica* sp. nov. (*Zygomycetes*: *Entomophthorales*) two pathogens of *Miridae* (*Heteroptera*) distinguished by pathological and nuclear features. Can. J. Bot. 63: 1469-1475.
Ben-Ze' ev I., Kenneth R. G. 1980. *Zoophthora phytonomi* and *Conidiobolus osmodes* (*Zygomycetes*: *Entomophthoraceae*), two pathogenes of *Hypera* species. (*Col.*: *Curculionidae*) coincidental in time and place. Entomophaga 25: 171-186.
Ben-Ze' ev I., Kenneth R. G. 1981a. *Zoophthora orientalis* sp. nov, a fungal pathogen of *Aphis citricola* (*Homoptera*: *Aphididae*), and two new combinations of other species of *Entomophthoraceae*. Phytoparasitica 9: 33-42.
Ben-Ze' ev I., Kenneth R. G. 1981b. *Zoophthora radicans* and *Zoophthora petchii* sp. nov. (*Zygomycetes*: *Entomophthorales*) two species of the „*sphaerosperma* — group" attacking leafhoppers and froghoppers (*Hom.*). Entomophaga 26:131-142
Ben-Ze' ev I., Kenneth R. G. 1982. Features-criteria of taxonomic value in the *Entomophthorales*: 1. A revision of the Batkoan classification. 2. A revision of the genus *Erynia* Nowakowski 1881 (*Zoophthora* Batko 1964). Mycotaxon 14: 393-475.
Ben-Ze' ev I., Kenneth R. G. 1986. A fourth family in the entomophthorales: *Neozygitaceae*, including *Neozygites* and a new genus, *Thaxterosporium*. In: Fundamental and applied aspects of invertebrate pathology. Eds. R. A. Samson, J. M. Vlak, D. Peters. Wageningen: 218.
Ben-Ze' ev I., Kenneth R. G., Bitton S., Soper R. S. 1984. The entomophthorales of Israel and their arthropod hosts: seasonal occurrence. Phytoparasitica 12 (3-4): 167-176.
Ben-Ze' ev I., Kenneth R. G., Uziel A. 1987. A reclassification of *Entomophthora turbinata* in *Taxterosperium* gen. nov., *Neozygitaceae* fam. nov. (*Zygomycetes*: *Entomophthorales*). Mycotaxon 28: 313-326.
Ben-Ze' ev I., Uziel A. 1979. *Monellia costalis* (Fitch), a new host for *Zoophthora radicans* (Brefeld) Batko and *Entomophthora planchoniana* Cornu (*Zygomycetes*: *Entomophthoraceae*) in Israel. Phytoparasitica 7: 159-167.
Ben-Ze' ev I., Zeling Y. 1984. *Entomophthora israelensis* sp. nov. (*Zygomycetes*: *Entomophthorales*), a fungal pathogen of gall midges (*Diptera*: *Cecidomyiidae*). Mycotaxon 21: 463-474.
Berdan H. 1938. Revision od the genus *Ancylistes*. Mycologia 30: 396-415.
Bitton S., Kenneth R., Ben-Ze' ev I. 1978. Zygospore overwintering and sporulative germination in *Triplosporium fresenii* (*Entomophthoraceae*) attacking *Aphis spiraecola* on *Citrus* in Israel. J. Invertebr. Pathol. 34: 295-302.
Blackwell M., Malloch D. 1989. Similarity of *Amphoromorpha* and secondary capilliconidia of *Basidiobolus*. Mycologia 81: 735-741.
Brefeld O. 1870. Entwicklungsgeschichte der *Empusa Muscae* und *Empusa radicans*. Bot. Ztg. 28: 161-166; (12): 177-186.

Brefeld O. 1877. Über die Entomophthoreen und ihre Verwandten. Bot.Ztg. 35: 345-355; 368-372.
Brefeld O. 1884. *Conidiobolus utriculosus* und *minor*. Untersuch. Ges. Mycol. 6: 35-72, 75-78.
Bridges C. H., Romaris W. M., Emmons C. W. 1962. Phycomycosis of horses caused by *Entomophthora coronata*. J. Am. Veter. Med. Assoc. 140: 673-677.
Bresadola J. 1892a. *Massospora staritizii* Bres. n.sp. Hedwigia 31: 133.
Bresadola J. 1982b. *Massospora staritizii* Bres. n.sp. Rev. Mycol. 14: 97.
Brobyn P., Wilding N. 1977. Invasive and developmental processes of *Enthomophthora* species infecting aphids. Trans. Brit. Mycol. Soc. 69: 349-366.
Brobyn P., Wilding N. 1987. Laboratory observations on the effect of humidity on the persistence of infectivity of conidia of the aphid pathogen *Erynia neoaphidis*. Ann. Appl. Biol. 110: 579-584.
Brobyn P., Wilding N., Clark S. J. 1985. The persistence of intectivity of conidia of the aphid pathogen *Erynia neoaphidis* on leaves in the field. Ann. Appl. Biol. 107: 365-376.
Brumpt E. 1940. Entomophorée pathogđne pour divers moustiques de la station expérimentale du domaine de Richelieu. Compt Rend. Hebd. Séanc. Acad. Sci. 211: 673-677.
Brumpt E. 1941. Entomophorées parasites des moustiques. Étude critique. Recherches personelles. Ann. Paras. Hum. Comp. 18: 112-114.
Bubak F. 1903. Beitrag zur Kenntnis einiger Phycomyceten. Beiblatt zu Hedwigia 42: 100-104.
Bucher G.E., MacLeod D. M. 1974. Rediscovery of *Tarichium megaspermum* (*Entomophthoraceae*) in Canadian cutworms (*Noctuidae*). J. Invertebr. Pathol. 23: 157-163.
Butt T. M., Wraight S. P., Galaini-Wraight S., Humber R. A., Roberts D. W., Soper R. S. 1988. Humoral encapsulation of the fungus *Erynia radicans* (*Entomophthorales*) by the patato leafhopper, *Empoasca fabae* (*Homoptera*: *Cicadellidae*). J. Invertebr. Pathol. 52: 49-56.
Carl K. P. 1975. An *Entomophthora* sp. (*Entomophthorales*: *Entomophthoraceae*) pathogenic to *Thrips* spp. (*Thysan.*: *Thripidae*) and its potential as a biological control agent in glasshouses. Entomophaga 20: 381-388.
Castner D. 1968. A *Conidiobolus*-like fungus destroying nematodes in Iowa. Mycologia 60: 440-443.
Cohn F. 1855. *Empusa muscae* und die Krankheit der Stubenfliegen. Verh. Keiserl. Leopold.-Carolin. Akad. Naturforsch. 25: 300-360.
Cohn F. 1870a. Pilz-Epidernien beiden Insekten. Jahres-Ber. Schles. Geselsch. Vaterland. Kultur. 47: 85-87.
Cohn F. 1875. Über eine neue Pilzkrankheit der Erdraupen. Beitr. Biol. Pflanz. 1: 58-86.
Coremans-Pelseneer J. 1974. Biologie des champignons du genere *Basidiobolus* Eidam 1886. Saprophytisme et pourvoir pathogne. Acta Zool. Path. Antverpiensia 60: 7-137.
Coremans-Pelseneer J. 1976. Note preliminaire sur l'isolement d'*Entomophthora* en Belgique. Bull. Soc. Mycol. Med. 5: 153-156.
Couch J. N., Andreeva R. V., Laird N., Nolan R. A. 1979. *Tabanomyces milkoi* (Dudka and Koval) emended, genus novum, a fungal pathogen of horseflies. Proc. Natl. Açad. Sci. U.S.A 76: 2299-2302.
Couch J. N. 1949. A new species of *Ancylistes* on a saccoderm desmid. J. Elisha Mitchell Sci. Soc. 65: 131-136.
Davidson J. G., Barron G. L. 1973. Nematophagous fungi. *Meristacrum*. Can. J. Bot. 51: 231-233.
Descals E., Webster J. 1984. Branched aquatic conidia in *Erynia* and *Entomophthora* sensu lato. Trans. Brit. Mycol. Soc. 83: 669-682.
Descals E., Webster J., Ladle M., Bass J. A.B. 1981. Variations in asexual reproduction in species of *Entomophthora* on aquatic insect. Trans. Brit. Mycol. Soc. 77: 85-102.
Domsch K. H., Gams W., Anderson T.-H. 1980. Compendium of soil fungi. London-New York-Toronto-Sydney-San Francisco.
Drechsler C. 1940. Three fungi destructive to free-living terricolous nematodes. J. Wash. Acad. Sci. 30: 240-254.
Drechsler C. 1951. An entomophthoraceous tardigrade parasite producing small conidia on propulsive cells in spicate heads. Bull. Torrey Bot. Club 78: 183-200.
Drechsler C. 1952. Widespread distribution of *Delacroixia coronata* and other saprophytic *Entomophthoraceae* in plant detritus. Science 115: 575-576.

Drechsler C. 1953. Three new species of *Conidiobolus* isolated from leaf mold. J. Wash. Acad. Sci. 43: 29-43.
Drechsler C. 1955a. Two new species of *Conidiobolus* that produce microconidia. Amer. J. Bot. 42: 793-803.
Drechsler C. 1955b. A small *Conidiobolus* with globose and with elongated secondary conidia. J. Wash. Acad. Sci. 45: 114-117.
Drechsler C. 1956. Supplementary development of *Basidiobolus ranarum* and *Basidiobolus haptosporus*. Mycologia 48: 655-676.
Drechsler C. 1961. Two species of *Conidiobolus* often forming zygospores adjecent to antheridium-like distentions. Mycologia 53: 278
Drechsler C. 1962. A small *Conidiobolus* with resting spores that germinate like zygospores. Bull. Torrey Bot. Club 89 (4): 233-240.
Drechsler C. 1964. An odorous *Basidiobolus* often producing conidia plurally and forming some diclinous sexual apparatus. Amer. J. Bot. 51: 770-777.
Drechsler C. 1965. A robust *Conidiobolus* with zygospores containing granular parietal protoplasm. Mycologia 57: 913-926.
Dunphy G. B., Nolan R. A. 1982. Cellular immune responses of spruce budworm larvae to *Entomophthora egressa* protoplasts and other test particles. J. Invertebr. Pathol. 39: 81-92.
Dunphy G. B., Chadwick J. M. 1985. Strains of protoplasts of *Entomophthora* egressa in spruce budworm larvae. J. Invertebr. Pathol. 45: 255-259.
Durnovo Z. P. 1935. Zabolevanie schtschelkunov *Agriotes obscurus* F. i *A. Sputator* L., vyzvannoe gribom *Entomophthora sphaerosperma* Fress. Zaschtsch. Rast.:151-152.
Dustan A. G. 1924. Studies on a new species of *Empusa* parasitic on the green apple bug (*Lygus* communis var. *novascotiensis* Knight) in the Annapolis Valley. Proc. Acadian Entomol. Soc. 9: 14-36.
Egina K., Ja., Tsinovskii Ja. P. 1972. Ispolzovanie entomoftorovych gribov v borbe c pautinnymi kleszczami. In: Patologia nasekomych i kleszczej. Ed. P. Tsinovskii. Riga: 95-110.
Eidam E. 1886.Basidiobolus, eine neue Gattung der Entomophthoraceen. Beitr. Biol. Pflanz. 4 (2): 181-251.
Eilenberg J., Bresciani J., Latgé J. P. 1986a. Primary spore formation and discharge in the genus *Entomophthora*. In: Fundamental and applied aspects of invertebrate pathology. Eds. R. A. Samson, J. M. Vlak and D. Peters. Wageningen: 182-185.
Eilenberg J., Bresciani J., Latgé J-P. 1986 b. Ultrastructural studies of primary spore formation and discharge in the genus *Entomophthora*. J. Invertebr. Pathol. 48: 318-324.
Eilenberg J., Bresciani J., Martin J. 1987. *Entomophthora* species with *E. muscae*-like primary spores on two new insect orders, *Coleoptera* and *Hymenoptera*. Nordic J. Bot.
Eilenberg J., Wilding N., Bresciani J. 1992. Isolation in vitro of *Strongwellsea castrans* (*Fungi: Entomophthorales*) a pathogen of adult cabbage root flies, *Delia radicum* (*Dipt.: Anthomyiidae*). Entomophaga 37(1): 65-77.
Emmons C. W., Bridges C. H. 1961. *Entomophthora coronata*, the etiologic agent of a phycomycosis of horses. Mycologia 53: 307-312.
Eremeeva A. M. 1925. *Entomophthora sphaerosperma* Fres. na gusenicach kapustnicy i na jablonnoj medjanice. Bol. Rast. 14: 100-103.
Evans H. C. 1988. Coevolution of entomogenous fungi and their insect hosts. In: Coevolution of Fungi with Plants and Animals. Eds. K. A. Pirozynski, D. L. Hawksworth. Academic Press. London-San Diego-New York-Berkeley-Boston-Sydney-Tokyo-Toronto.
Evlakhova A. A. 1974. Entomo-patogennye griby. Izd. Nauka. Leningrad.
Fries R. E. 1899. *Basidiobolus myxophilus* en ny phycomycet. Bih. Svenska Vet. Akad. Handl. 25: 1-15.
Garbowski L. 1927. *Empuca aulicae* Reich. w związku z klęską sówki chojnówki, *Panolis flammea* Schiff. w lasach Wielkopolski i Pomorza w r.1923/24. Państw. Inst. Nauk.-Roln w Bydgoszczy, 4: 25-44. (in Polish; French summ.).
Garrison R. G., Mariat F., Boyd K. S., Tally J. F. 1975. Ultrastructural and electron cytochemical studies of *Entomophthora coronata* . Ann. Microbiol. (Inst. Pasteur) 126, ser. B: 149-173.
Giard A. 1888. Fragments biologigues XI. Sur quelques entomophthorées. Bull. Sci. France Belgique 19: 298-309.

Giard A. 1889. Sur quelques types remarquables de champignons entomophytes. Bull. Sci. France Belgique 20: 197-224.
Gilbert E.F., Khoury G. H., Pore R. S. 1970. Histopathological identification of *Entomophthora* phycomycosis. Arch. Pathol. 90: 583-587.
Gäumann E. 1954. Die Pilze. Basel.
Gustafsson M. 1965. On species of the genus *Entomophthora* Fres. in Sweden. I. Classification and distribution. Lantbrukshogsk. Ann. 32:102-212.
Grobler J. H., MacLeod D. M., DeLyzer A. J. 1962. The fungus *Empusa aphidis* Hoffmann parasitic on the woolly pine needle aphid, *Schizolachnus pini-radiatae* (Davidson). Canad. Entomol. 94: 46-49.
Harcourt D. G., Guppy J. C., MacLeod D. M., Tyrrell D. 1974. The fungus *Entomophthora phytonomi* pathogenic to the alfalfa weevil, *Hypera postica.* Canad. Entomol. 106: 1295-1300.
Humber R. A. 1976. The systematics of the genus *Strongwellsea* (*Zygomycetes*: *Entomophthorales*). Mycologia 68: 1042-1060.
Humber R. A. 1981a. An alternative view of certain taxonomic criteria used in the *Entomophthorales* (*Zygomycetes*). Mycotaxon 13: 191-240.
Humber R. A.1981b. *Erynia* (*Zygomycetes*: *Entomophthorales*): validations and new species. Mycotaxon 13: 471-480.
Humber R. A. 1984a. *Eryniopsis* a new genus of the *Entomophthoraceae* (*Entomophthorales*). Mycotaxon 21: 257-264.
Humber R. A. 1984b. The identity of *Entomophthoraceae* attacking *Lepidoptera* (*Entomophthorales*: *Entomophthoraceae*). Mycotaxon 21: 265-272.
Humber R. A. 1984c. Fundations to an evolutionary classification of the entomophthorales (Zygomycetes). In: Fungus-Insect Relationships. Eds. Q. Wheeler, M. Blackwell. Columbia Univ. Press. New York.
Humber R. A. 1989. Synopsis of a revised classification for the *Entomophthorales* (*Zygomycotina*). Mycotaxon 34: 441-460.
Humber R. A., Ben-Ze' ev I. 1981. *Erynia* (*Zygomycetes*: *Entomophthorales*): emendation, synonymy and transfers. Mycotaxon 8: 506-516.
Humber R. A., Feng M. G. 1991. *Entomophthora chromaphidis* (*Entomophthorales*): the correct identification of an aphid pathogen in the Pacific Northwest and elsewere. Mycotaxon 41: 497-504.
Humber R. A., Moraes G. J., Santos J. M. 1981. Natural infection of *Tetranychus evansi* (*Acarina: Tetranychidae*) by a *Triplosporium* sp. (*Zygomycetes*: *Entomophthorales*) in North-Eastern Brazil. Entomophaga 26: 421-425.
Humber R. A., Ramoska W. A. 1986. Variation in entomophthoralean life cycles: practical implications. In: Fundamental and applied aspects of invertebrate pathology. Eds. R. A. Samson, J. M. Vlak, D. Peters. Wageningen: 190-193.
Humber R. A., Soper R. S., Wilding N., Remaudière G. 1977. The identification of certain widely studied strains of *Entomophthora* pathogenic for aphids. Mycotaxon 5: 307-310.
Hutchison J. A. 1962. Studies on a new *Entomophthora* attacking calyptrate flies. Mycologia 54: 258-271.
Hutchison J. A. 1963. The genus *Entomophthora* in the Western Hemisphere. Trans. Kansas Acad. Sci. 66: 237-254.
Kaufmann O. 1941. Der Kleeblattkafer (*Phytonomus punctatus* F.), ein Schadling von Klee und Luzerne. Zentrbl. Bakt. Paras. Infektionskrankh. II. Abt., 104: 87-117.
Keller S. 1978. *Entomophthora gigantea* sp. nov. and. *E. caroliniana* (Thaxter) comb. nov. two pathogens of *Tipula paludosa* Meig. Sydowia 31: 87-93.
Keller S. 1980. Two new species of the genus *Zoophthora* Batko (*Zygomycetes*, *Entomophthorales*): *Z. lanceolata* and *Z. crassitunicata.* Sydowia 33: 167-173.
Keller S. 1981. *Entomophthora erupta* (*Zygomycetes*: *Entomophthoraceae*) als Pathogen von *Notostira elongata* (*Heteroptera: Miridae*). Mitt. Schweiz. Entomol. Gesellsch. 54: 57-64.
Keller S. 1982. *Zoophthora elateridiphaga* (*Zygomycetes*: *Entomophthoraceae*) als Ursache von

Massensterben der Wanze *Notostiraa elongata* (*Heteroptera: Miridae*). Mitt. Schweiz. Entomol. 55: 289-296.
Keller S. 1984. *Entomophthora muscae* als Artenkomplex. Mitt. Schweiz. Entomol. Gesellsch. 57: 131-132.
Keller S. 1987. Arthropod-pathogenic *Entomophthorales* of Switzerland. I. *Conidiobolus, Entomophaga* and *Entomophthora.* Sydowia 40: 122-167,
Keller S. 1991. Arthropod-pathogenic *Entomophthorales* of Switzerland. II. *Erynia, Eryniopsis, Neozygites, Zoophthora* and *Tarichium.* Sydowia 43: 39-122.
Keller S., Wuest J. 1983. Observations sur trois espèces de *Neozygites* (*Zygomycetes*: *Entomophthoraceae*). Entomophaga 28: 123-134.
Keller S., Wilding N. 1985. *Entomophthora brevinucleata* sp. nov. (*Zygomycetes, Entomophthoraceae*), a pathogen of gall midges (*Dipt.*: *Cecidomyiidae*). Entomophaga 30: 55-63.
Kenneth R. G. 1977. *Entomophthora turbinata* sp. nov. a fungal parasite of the peach trunk aphid, *Pterochlorides persicae* (*Lachnidae*). Mycotaxon 6: 381-390.
Kevorkian A. G. 1937. Studies in the *Entomophthoraceae*: I. Observations on the genus *Conidiobolus*. J. Agric. Univ. Puerto Rico. 21: 191-200.
King D. S. 1976a. Systematics of *Conidiobolus* (*Entomophthorales*) using numerical taxonomy. I. Biology and cluster analysis. Can. J. Bot. 54: 45-65.
King D. S. 1976b. Systematics of *Conidiobolus* (*Entomophthorales*) using numerical taxonomy II. Taxonomic considerations. Can. J. Bot. 54: 1285-1296.
King D. S. 1977. Systematics of *Conidiobolus* (*Entomophthorales*) using numerical taxonomy III. Descriptions of recognized species. Can. J. Bot. 55: 718-729.
King D. S. Jong S. C. 1976. Identity of the etiological agent of the first deep entomophthoraceous infection of man in the United States. Mycologia 68: 181-183.
King D. S., Lahn E., Jong S. C. 1976. *Conidiobolus thromboides* isolated in Maryland. Mycologia 68: 939-942.
Klein M. G., Coppel H. C. 1973. *Entomophthora tenthredinis*, a fungal pathogen of the introduced pine sawfly in northwestern Wisconsin. Ann. Entom. Soc. Amer. 66: 1178-1180.
Kobayasi Y. 1951. Notes on fungi. (1) On the newly found genus *Massospora* from Japan. J. Jap. Bot. 26: 21-23.
Koval E. Z. 1965. Materialy do vivoja entomofilnych gribov na Ukraini. Ukr. Bot. Žurn. 5: 59-61.
Koval E. Z. 1974. Opredelitel entomofilnych gribov SSSR. Izd. Naukova Dumka. Kiev.
Koval E. Z., Savtschenko E. Ja. 1965. Novi dlja Ukraini entomofilni gribi na komarachdovgonogach i limonidach. Dop. AN USSR 12: 1645-1647.
Krejzova R. 1973. The pathogenic effect of the fungus *Basidiobolus* sp. on the larvae of *Galleria mellonella* L. Vestn. Českosl. Spol. Zool. 37: 273-274.
Krejzova R. 1981. Surface structure of the fungus *Zoophthora radicans*. Časop. Českoslov. Ved. Spol., Mycol. 35: 57-63.
Kushida T., Katari K. 1975.Infection of *Aedia leucomelas L. (Lepidoptera: Noctuidae)* by an *Entomophthora* species of the *"grylli"* type in Japan. Appl. Entomol. Zool. 10(3): 226-230.
Lagerheim G. V. 1898. Mycologische Studien. I. Beitrage zur Kenntnis der parasitischen Pilze, 1-3. Bihang till K. Svenska Vet. Acad. Handl. 24: 21.
Lakon G. 1919a. Die Insektenfeinde aus der Familie der Entomophthoreen. Z. angew. Entom. 5: 161-216.
Lakon G. 1919b. Bemerkungen uber die Überwinterung von *Empusa Muscae*. Z. angew. Entom. 5: 286-290.
Lakon G. 1935. Entomophthoraceen-studien I-IV. Z. Angew. Entomol, 22: 75-79.
Latgé J. P. 1975a. Croissance et sporulation de 6 espèces d'*Entomophthorales* . 1. Influence de la nutrition carbonée. Entomomophaga 20: 201-207.
Latgé J. P. 1975b. Croissance et sporulation de 6 espèces d'*Entomophthorales* II. Influence de diverses sources d'azote. Mycopathologia 57: 53-57.
Latgé J.-P., de Bièvre C. 1976. Influence des lipides et acides gras du jaune d'oeuf sur la croissance et la sporulation des *Entomophthorales*. Ann. Microbiol. (Inst. Pasteur), Ser. A, 127: 261-274.
Latgé J. P., Boucias D. G. 1984. Intraspecific variability in *Conidiobolus obscurus*. J. Gen. Appl. Microbiol. 30: 135-150.

Latgé J.P., King D.S., Papierok B. 1980. Synonymie de *Entomophthora virulenta* Hall et Dunn et de *Conidiobolus thromboides* Drechser. Mycotaxon 11: 255-268.
Latgé J.P. Papierok B. 1988. Aphid pathogens. In: Aphids. Their biology, natural enemies and control. Ed. W. Helle. World crop pests: 28: 323-336.
Latgé J.P., Soper R.S., Madore C.D. 1977. Media suitable for industrial production of *Entomophthora virulenta* zygospores. Biotechn. Bioengineer. 19: 1269-1284.
Le Rü B., Silvie P., Papierok B. 1985. L'entomophthorale *Neozygites fumosa* pathogène de la cochenille du manioc *Phenacoccus manihoti* (*Hom.: Pseudococcidae*) en Republique Populaire du Congo. Entomophaga 30: 23-29.
Lindley J. 1924. *Isochilus prolifer*. Bot. Reg. 10: 825.
Lipa J. J. 1963. Polska analityczna bibliografia chorób owadów. Część I. Choroby i mikrobialne zwalczanie szkodliwych owadów. Prace Nauk. Inst. Ochr. Roślin 5(1): 3-100.
Lipa J. J. 1976. Fungi isolated from five noctuid species (*Noctuidae: Lepidoptera*). Prace Nauk. Inst. Ochr. Rośl. 18(2): 25-48.
Liro J. I., 1954. *Tarichium pallidum* Roiv. n.sp. Mycotheca Fennica, Schedae, Fasc. 18: 96.
Li Zeng-Zhi. 1986. *Erynia anhuiensis* a new pathogen of aphids. Acta. Mycol. Sin. 5: 1-6.
Li Zeng-Zhi., Humber R. A. 1984. *Erynia pieris* (*Zygomycetes*: *Entomophthoraceae*). A new pathogen of *Pieris rapae* (*Lepidoptera: Pieridae*): description, host range and notes on *Erynia virescens*. Can. J. Bot. 62: 653-663.
Lohde G. 1874. Über einige neue parasitische Pilze. Tageblatt d. 47. Versamml. deutscher Naturf. Ärzte zu Breslau: 203-206.
MacLeod D. M. 1956. Notes of the genus *Empusa* Cohn. Canad. Entomol. 34: 16-26.
MacLeod D. M., Müller-Kögler E. 1970. Insect pathogens: species originally deseribed from their resting spores mostly as *Tarichium* species (*Entomophthorales*: *Entomophthoraceae*). Mycologia 62: 33-66.
MacLeod D. M., Müller-Kögler E. 1973. Entomogenous fungi: *Entomophthora* species with pear-shaped to almost spherical conidia (*Entomophthorales*: *Entomophthoraceae*). Mycologia 65: 823-893.
MacLeod D. M., Müller-Kögler E., Wilding N. 1976. *Entomophthora* species with *E. muscae*-like conidia. Mycologia 68: 1-29.
MacLeod D. M., Tyrrell D. 1979. *Entomophthora crustosa* n.sp. a sa pathogen of the forest tent caterpillar, *Malacosoma disstria (Lepidoptera: Lasiocampidae)*. Canad. Entomol. 111: 1137-1144.
MacLeod D. M., Tyrrell D., Carl K. P. 1976. *Entomophthora parvispora* sp. nov., a pathogen of *Thrips tabaci*. Entomophaga 21: 307-312.
McCabe D. E., Humber R. A., Soper R. S. 1984. Observation and interpretation of nuclear reductions during maturation and germination of entomophthoralean resting spores. Mycologia 76: 1104-1107.
Miętkiewski R., Soper R. S., Balazy S. 1981. Notes on *Zoophthora occidentalis* (Taxter) Batko (*Entomophthorales*: *Entomophthoraceae*). Mycotaxon 13: 41-49.
Miętkiewski R., van der Geest L. P. S., Bałazy S. 1986. Preliminary notes on the pathogenicity of some *Erynia* strains (*Mycophyta*: *Entomophthoraceae*) towards larvae of *Pieris brassicae*. Z. angew. Entom. 102: 499-504.
Miller M. W., Keil C. B. 1990. Redescription of *Pandora gloeospora (Zygomycetes*: *Entomophthorales*) from *Lycoriella mali* (*Diptera*: *Sciaridae*). Mycotaxon 38: 227-231.
Milner R. J. 1985. *Neozygites acaridis* (Petch) comb. nov., an entomophthoralean pathogen of the mite *Macrocheles peregrinus* in Australia. Trans. Brit. Mycol. Soc. 85: 641-647.
Milner R. J., Mahon J. R., Brown W. V. 1983. A taxonomic study of the *Erynia neoaphidis* Remaudière and Hennebert (*Zygomycetes*: *Entomophthoraceae*) group of insect pathogenic fungi, together with a description of the new species *Erynia kondoiensis*. Austral. J. Bot. 31: 173-188.
Millstein J. A., Brown G. C., Nordin G. L. 1983. Microclimatic moisture and conidial production in *Erynia* sp. (*Entomophthorales*: *Entomophthoraceae*). In vivo moisture balance and conidiation phenology. Environ. Entomol. 12: 1339-1343.
Molliard M. 1918. Sur la vie saprophytique d'un *Entomophthora* (*E. Henrici* n.sp.). Compt. Rend. Acad. Sci Paris 167: 958-960.

Müller-Kögler E. 1959. Zur Isolierung und Kultur Insektenpathogeger Entomophthoraceen. Entomophaga 3: 261-275.
Napiórkowska-Kowalik J., Machowicz-Stefaniak Z. 1986. Udział pasożytniczych owadów i grzybów w regulacji liczebności sówkowatych (*Lepidoptera, Noctuidae*) występujących na plantacjach kapusty i buraków cukrowych. Pol. Pismo Ent. 56: 687-700.
Narasimhan M. J. 1970. Entomogenous fungi and possibility of their use for biological control of insect pests in India. Indian Phytopath. 23: 16-26.
Narasimhan M. J., Thirumalachar M. I. 1977. Entomogenous fungus attacking scale insects on coffee leaves in India Abstr. 2nd. Int. Mycol. Congr. Tampa, Florida, 2: 466.
Nemoto H., Aoki J. 1975. *Entomophthora floridana* (*Entomophthorales: Entomophthoraceae*) attacking the Sugi spider mite, *Oligonychus hondoensis* (*Acarina: Tetranychidae*) in Japan. Appl. Ent. Zool. 10: 90-95.
Nieuwland J. A. 1916. Critical notes of new and old genera of plants VII. Amer Midl. Nat. 4: 374-378.
Nordin G. L., Brown G. C., Millstein A. 1983. Epizootic phenology of *Erynia* disease of the alfalfa weevil *Hypera postica* (Gyllenhal), (*Coleoptera: Curculionidae*), in Central Kentucky. Environ. Entomol. 12: 1350-1355.
Nowakowski L. 1877. Die Kopulation bei einigen Entomophthoreen. Bot. Ztg. 34: 216-222.
Nowakowski L. 1881. (On a group of *Entomophthoreae*). Dzienn. III Zjazdu Lek. Przyr. Polskich 3: 67 (in Polish).
Nowakowski L. 1883. *Entomophthoreae.* Przyczynek do znajomości pasorzytnych grzybków sprawiających pomór owadów. Pam. Akad. Umiej. Kraków, Wydz. Mat.-Przyr. 8: 153-179.
Otvos I. S., Tyrrell D., MacLeod D. M. 1973. Two species of *Entomophthora* pathogenic to the Eastern hemlock looper (*Lepidoptera: Geometridae*) in Newfoundland. Canad. Entomol. 105: 1435-1441.
Papierok B., Torre V. B. L., Arnault M. 1984. Contiribution a l'etude de la specificite parasitaire du champignon entomophthogène *Zoophthora radicans* (*Zygomycetes, Entomophthorales*). Entomophaga 29: 109-119.
Papierok B., Aeschlimann J. P., Loan C. 1986. Two entomophthoralean fungi occuring on *Hypera postica* in southern France. J. Invertebr. Pathol. 48: 377-380.
Petch T. 1926. Studies on entomogenus fungi. IX. *Empusa lecanii* Zimm. Trans. Brit. Mycol. Soc. 11: 254-258.
Petch T. 1931a. Notes on entomogenous fungi. Trans.Brit Mycol. Soc. 16: 209-245.
Petch T. 1932. A list of the entomogenous fungi of Great Britain. Trans. Brit. Mycol. Soc. 17: 170-178.
Petch T. 1934. Notes on entomogenus fungi. 86. *Entomophthora aphrophorae* Rostrup. 87. *Empusa muscae* Cohn. Trans. Brit. Mycol. Soc. 19: 161-193.
Petch T. 1937. Notes on entomogenous fungi. Trans. Brit. Mycol. Soc. 21: 34-67.
Petch. T. 1940. An *Empusa* on a mite. Proc. Linn. Soc. New South Wales 65: 259-260.
Petch T. 1944. Notes on entomogenous fungi. Trans. Brit. Mycol. Soc. 27: 81-93.
Petch T. 1948. A revised list of British entomogenous fungi. Trans. Brit. Mycol. Soc. 31: 286-304.
Pfitzer E. 1872. *Ancylistes closterii*, ein neuer Algen-Parasit aus der Ordnung der *Phycomycetes.* König. Preuss. Akad. Wissensch. (Mai): 379-398.
Prasertphon S. 1963. Pathogenicity of different strains of *Entomophthora coronata* (Costantin) Kevorkian for larvae of the greater wax moth. J. Insect.Pathol. 5: 174-181.
Raciborski M. 1896. Mycologische Studien I. Kariokinese bei *Basidiobolus ranarum* Eidam. Anz. Akad. Wissenschaft. Krakau, (November 1896): 378-382
Raciborski M. 1897. Einfluss ausserer Bedingungen auf die Wachstumweise des *Basidiobolus ranarum.* Flora 82: 107-132.
Raciborski M. 1910. Mycotheca polonica. Kosmos 35 (7-9): 774-781.
Rees O. L. 1932. The morphology and development of *Entomophthora fumosa.* Amer. J. Bot. 19: 101-203.
Remaudière G., Keller S., Papierok B., Latgé J. P. 1976. Considérations systematiques et biologiques sur quelques espèces d'*Entomophthora* du groupe *sphaerosperma* pathogènes d'insectes (*Phycomycetes: Entomophthoraceae*). Entomophaga 21 163-177.

Remaudière G., Hennebert G. L. 1980. Revision systematique de *Entomophthora aphidis* Hoffm. in Fres. Description de deux nouveaux pathogènes d'Aphides. Mycotaxon 11: 269-321.
Remaudière G., Keller S. 1980. Revision systematique des genres d'*Entomophthoraceae* a patentialité entomopathogène. Mycotaxon 11: 323-338.
Riddle L. W. 1906. On the cytology of the *Entomophthoraceae*. Amer. Acad. Arts. Sci. 42: 177-197.
Rostrup O. 1916. Bidrag til Danmarks Svampflora. I. *Entomophthoraceae*. Dansk Bot. Arkiv. 2: 3-4.
Rozsypal J. 1951. Prispevek k biologickemu boji proti skudcum abili (novy parasit larev hrbace osenniho). Sborn. Českol. Akad. Zemed. 24: 85-94.
Sawyer W. H. 1931. Studies on the morphology and development of an insect-destroying fungus, *Entomophthora sphaerosperma*. Mycologia 23: 411-432.
Schweizer G. 1947. Über die Kultur von *Empusa muscae* Cohn und aderen Entomophthoraceen auf kaltsterilisierten Nahrboden. Planta 35: 132-176.
Smith M. F., Callaghan A. A. 1987. Quantitative survey of *Conidiobolus* and *Basidiobolus* in soils and litter. Trans. Brit. Mycol. Soc. 89: 179-185.
Snell W. H., Dick E. A. 1957. A glossary of mycology. Harward Uniw. Press, Cambridge.
Soper R. S. 1963. *Massospora levispora*, a new species of fungus pathogenic to the cicada *Okanagana rimosa*. Can. J. Bot. 41: 875-878.
Soper R. S. 1974. The genus *Massospora* entomopathogenic for cicadas. Part I. Taxonomy of the genus. Mycotaxon 1: 13-40.
Soper R. S. 1981. A new cicada pathogens: *Massospora cicadettae* from Australia and *Massospora paharíae* from Afghanistan. Mycotaxon 13: 50-58.
Soper R. S., Holbrook F. R., Majchrowicz I., Gordon C. C. 1976. Production of *Entomophthora* resting spores for biological control of aphids. Technical Bulletin 76: 1-15.
Soper R. S. MacLeod D. M. 1963. Spore morphology of *Entomophthora fresenii* Nowakowski. J. Insect. Pathol. 5: 478-482.
Soper R. S., MacLeod D. M. 1981. Descriptive epizootiology of an aphid mycosis. U. S. Dep. Agri. Techn. Bull. 1632, 17 pp.
Soper R. S., May B., Martinell B. 1983. *Entomophaga grylli* enzyme polymorphism as a technique for pathotype identification. Envir. Entomol. 12: 720-723.
Soper R. S. Shimazu D., Humber R. A., Ramos M. E., Hajek A. E. 1988. Isolation and characterization of *Entomophaga maimaiga* sp. nov., a fungal pathogen of gypsy moth, *Lymantria dispar*, from Japan. J. Invertebr. Pathol. 51: 229-241.
Soderhall K., Hall L., Unestam T., Nyhlen L. 1979. Attachment of phenoloxidase to fungal cell walls in arthropod immunity. J. Invertebr. Pathol. 34: 285-294.
Speare A. T. 1912. Fungi parasitic upon insects injurious to sugar cane. Rep. Work Exp. Sta. Hawaiian Sugar Plant. Assoc. Exp. Sta. Bull. 12, Path. Physiol. Ser. 14: 1012.
Speare A. T. 1922. Natural control of the citrus mealy bug. U. 5. Dept. Agric. Bull. 117, 18 pp.
Srinivasan M. C., Thirumalachar M. J. 1964. On the identity of *Entomophthora coronata*. Mycopathol. Mycol. Appl. 24: 294-296.
Srinivasan M. C., Thirumalachar M. J. 1967a. Evaluation of taxonomic characters in the genus *Conidiobolus*, with key to known species. Mycologia 59: 698-713.
Srinivasan M. C., Thirumalachar M. J. 1967b. Studies on *Basidiobolus* species from India with discussion on some characters used in the speciation of the genus. Mycopath. Mycol. Appl. 33: 56-64.
Stadler H. 1941. Massensterben einer Fliege (*Sapromyza* 4-*punctata*) L. an *Empusa echinospora* Thaxter. Ent. Z. 55: 129-134.
Staritz R. 1892. *Massospora richteri* n. sp. Hedwigia 31: 41-42.
Świeżyńska H., Górnaś E. 1976. Owadobójcze grzyby na niektórych gatunkach boreczników (*Hymenoptera*: *Diprionidae*) w latach 1971-1975. Sylwan 8: 47-56.
Thaxter R. 1888. The *Entomophthoreae* of the United States. Mem. Boston Soc. Nat. Hist. 4: 133-201.
Thaxter R. 1914. On certain peculiar fungus parasites of living insects. Bot. Gaz. 58:235-253.
Thoizon G. 1967. *Entomophthora pyriformis* sp. n., entomophthorale parasite de puceron. Entomophaga 12: 303-307.
Thor S. 1930. Über einzellige Parasiten in verschiedenen Acarina. I. Z. Parasitenk. 2: 551-570.

Tsintsadze K. V., Vartapetov S. G. 1976. Novyj entomopatogennyj grib *Entomophthora adjarica* sp. n. (*Phycomycetes, Entomophthoraceae*), porażajuszczyj obyknovennogo pautnistogo kleszcza *Tetranychus urticae* Koch. Bull. Acad. Sci. Georgian SSR 83 (2): 465-468.

Tucker B. E. 1981. A review of the non-entomogenous *Entomophthorales*. Mycotaxon 13: 481-505.

Turian G. 1952. Epizootic à *Entomophthorée* chez les cicadelles de la région de Géneve. Mitt. Schweiz. Ent. Gesellsch. 25: 44-46.

Turian G. 1957. Entomo-mycoses dans la région de Gèneve. Mitt. Schweiz. Entomol. Ges. 30: 93-98.

Turian G., Wuest I. 1969. Mycoses à Entomophthoracées frappant des populations de Fourmis et de Drosophiles. Mitt. Schweiz. Entomol. Gesellsch. 42: 197-201.

Turian G., Wuest J. 1977. Description complementaire de *Zoophthora* (*Entomophthora*) *myrmecophaga* Turian & Wuest, agent d'une mycose chez *Serviformica fusca* L. Trans. Brit. Mycol. Soc. 68: 134-137.

Tyrrell D., MacLeod D. M. 1972. A taxonomic proposal regarding *Delacroixia coronata* (*Entomophthoraceae*). J. Invertebr. Pathol. 20: 11-13.

Ubrizsy G., Vörös J. 1966. A new conception in the review on the phylogeny and system of fungi. Acta Bot. Acad. Sci. Hung. 12: 199-220.

Ullyett G. O., Schönken D. B. 1940. A fungus disease of *Plutella maculipennis* Curt. in South Africa, with notes on the use of entomogenous fungi in insect control. Dep. Agric. Sci. Entomol. Ser., 5, Sci. Bull. 218:

Urbańczyk M., Zabża A., Bałazy S., Peczyńska-Czoch W. 1992. Laboratory culture media and enzyme activity of some entomopathogenic fungi of *Zoophthora* (*Zygomycetes*: *Entomophthoraceae*). J. Invertebr. Pathol. 59: 250-257.

Vandenberg J. D., Soper R. S., 1975. Isolation and identification of *Entomophthora* spp. Fres. (*Phycomycetes*: *Entomophthorales*) from the spruce budworm *Choristoneura fumiferana* Clem. (*Lepidoptera*: *Tortricidae*). J. New York Entom. Soc. 83: 245-255.

Viegas A. P. 1939. *Empusa dysderci* n.sp., uno novo parasita de *Dysdercus*. Jorn. Agron. 2: 229-258.

Vuillemin P. 1886. Etudes biologiques sur les champignons. Bull. Soc. Sci. Nancy Ser. 19: 33-172.

Vuillemin P. 1900. Developpement des azygospores chez les Entomophthorées. Compt. Rend. Assoc. Franc. pour l'avance des sciences. Congres de Paris.

Waterhouse G. M. 1973. *Entomophthorales*. In: The fungi. An advanced treatise. Ed..G. C. Ainsworth, F. K. Sparrow and A. S. Sussman. T. IV b.

Waterhouse M., Brady B. L. Key to the species of *Entomophthora* sensu lato. Bull. Brit. Mycol. Soc. 16: 113-143.

Weber H. 1939. Beobachtungen über die Wirkung von *Empusa weberi* Lakon auf die Larvae von *Raphidia ophiopsis* L. Z. angew. Entomol. 26: 522-535.

Webster J., Sanders P.F., Descals E. 1978. Tetraradiate aquatic propagules in two species of *Entomophthora*. Trans. Brit. Mycol. Soc. 70: 472-479.

Weiser J. 1965. Notes on two new species of the genus *Tarichium* Cohn *(Entomophthoraceae)*. Česka Mykol. 19: 201-204.

Weiser J., Batko A. 1966. A new parasite of *Culex pipiens* L., *Entomophthora destruens* sp. nov. (*Phycomycetes*, *Entomophthoraceae*). Folia Parasitol. (Praha), 13: 144-149.

Weiser J., Stary P. 1967. La chicharra *Diceroprocta biconica* Walker, nuevo huesped en Cuba del hongo *Massospora cicadina* Peck 1870. Poeyana, Ser. A, 35: 1-6.

Wróblewski A., Siemaszko W. 1933. Fungi polonici selecti exsiccati. Decades 1-2. Schedae ad Herbarium. 1 p.

Yendol W. G., Paschke J. D. 1967. Infection of a looper complex by *Entomophthora sphaerosperma*. J. Invertebr. Pathol. 9. 274-276.

Zimmermann A. 1901. De dietrlijke Vijanden der Koffiecultuur op. Iava Deel. II Meded. Lands. Plantent. 44: 25-27.

Zimmermann G. 1978. Zur Biologie, Untesuchungs-methodik und Bestimmung von Entomophthoraceen *(Phycomycetes: Entomophthorales)* an Blattlausen. Z. angew. Entomol. 85 (3): 241-252.

Zimmermann G., Huger A. M. 1984. Neuere Befunde uber *Conidiobolus tenthredinis* (*Zygomycetes, Entomophthoraceae*) ein Pathogen von Blattwespen-larven (*Tenthredinidae*). Nachrichtenbl. Deutsch. Pflanzenschutzdienst. 36: 39-43.

OWADOMORKOWE — *ENTOMOPHTHORALES*

Opracował

Stanisław Bałazy

OWADOMORKOWE
ENTOMOPHTHORALES

CHARAKTERYSTYKA OGÓLNA

Morfologia i rozwój. Rząd owadomorkowych (*Entomophthorales*) zaliczany jest do klasy sprzężniaków — *Zygomycetes* (*Zygomycotina*). Oprócz właściwego całej klasie procesu gametangiogamii wspólną cechą zaliczanych tutaj gatunków jest zdolność wytwarzania aktywnie odrzucanych konidiów na nierozgałęzionych lub rozgałęzionych trzonkach konidialnych. U niektórych form zoopatogenicznych mechanizm odrzucania konidiów uległ uwstecznieniu poprzez przystosowanie do niespecyficznej zoochorii. Grzybnia wegetatywna należących do tego rzędu gatunków jest zazwyczaj strzępkowa i stosunkowo rozległa — zwłaszcza u form prowadzących saprofityczny tryb życia — przy czym strzępki zazwyczaj podzielone są błonami poprzecznymi na jedno- lub wielojądrowe odcinki. U form pasożytniczych grzybnia rozwija się bądź w postaci typowo strzępkowej, bądź też w postaci jednokomórkowych ciał strzępkowych. Powstają one w jamie ciała gospodarza przez fragmentację strzępki infekcyjnej na bryłki, względnie pasemka plazmatyczne, zwane protoplastami, oraz późniejszy ich wzrost i namnażanie się drogą podziałów lub pączkowania, względnie poprzez rozpad strzępek na poszczególne komórki. Obydwa typy fragmentacji mogą występować również w kulturach sztucznych, zwłaszcza na pożywkach płynnych. Ciała strzępkowe mogą mieć kształt regularnie kulisty, owalny, elipsoidalny, ameboidalny lub wydłużony — w postaci odcinków strzępek często pogrubionych i na końcach zaokrąglonych, nierzadko z uwypukleniami, wyrostkami lub nieregularnymi, krótkimi odgałęzieniami (Fig. 1). W różnych fazach procesu chorobowego powodowanego przez pasożytnicze owadomorki mogą występować następczo bądź różne postacie protoplastów i ciał strzępkowych bądź grzybni strzępkowej, zróżnicowane pod względem morfologii i spełnianych funkcji; np. u niektórych gatunków z rodzaju *Neozygites* ciała strzępkowe funkcjonujące jako gametangia różnią się od ciał strzępkowych, z których wyrastają trzonki konidialne. Z kolei we wczesnych stadiach rozwoju gatunku *Entomophaga tenthredinis*, ciała strzępkowe wewnątrz gospodarza mają postać mniej więcej równowąskich segmentów strzępek, podczas gdy w okresie zaawansowanego zarodnikowania konidialnego obok grzybni strzępkowej występują również ciała strzępkowe polimorficzne. W przypadkach

patogenów zwierząt bezkręgowych postać dyspersyjna grzybni (protoplasty i różne formy ciał strzępkowych) związana jest zazwyczaj z okresem rozwoju w żywym jeszcze gospodarzu, podczas gdy po jego śmierci następuje rozwój grzybni strzępkowej ze strukturami zarodnikotwórczymi. Elementami tej grzybni o specjalnych funkcjach są trzonki konidialne, pseudocystydy i chwytniki (ryzoidy). Komórki grzybni, wraz z ciałami strzępkowymi, zazwyczaj są wielojądrowe (oligo- lub polikariotyczne), tylko w rodzaju *Basidiobolus* zarówno komórki jak i trzonki konidialne oraz zarodniki są jednojądrowe (monokariotyczne), podobnie jak komórki zarodnikotwórcze i konidia u gatunków z rodzajów *Zoophthora* i *Strongwellsea*. Zróżnicowanie budowy jąder oraz ich liczba w poszczególnych komórkach plechy oraz w zarodnikach są ważnymi cechami owadomorkowych, często o charakterze kryteriów taksonomicznych. Ze względu na strukturę wyróżnia się trzy typy jąder.

1. Jądra bazydioboloidalne (Fig. 2) są duże, kuliste, owalne lub elipsoidalne, z dużym jąderkiem w centrum, łatwo wyróżnialne nawet w niebarwionym materiale, chociaż słabo barwiące się karminem, orceiną lub brunatem Bismarcka. Są one charakterystyczne dla rodzaju *Basidiobolus*, reprezentującego monotypową rodzinę *Basidiobolaceae*. Zazwyczaj występują w komórkach pojedynczo.

2. Jądra ancylistoidalne (Fig. 3) są drobne, o średnicy nie przekraczającej 2.5 μm, przeważnie znacznie mniejsze, z maleńkim, centralnie położonym jąderkiem, słabo lub w ogóle nie barwiące się wyżej wymienionymi barwnikami, wykazujące jednak normalną reakcję barwną Feulgena. Są charakterystyczne dla rodzin *Ancylistaceae* i *Meristacraceae*; i zwykle występują w komórkach w liczbie od kilkudziesięciu do ponad stu.

3. Jądra entomoftoroidalne (Fig. 4) są stosunkowo duże, 2.5-10 μm średnicy, kuliste, owoidalne, elipsoidalne lub wrzecionowate, dobrze barwiące się zwykłymi barwnikami jądrowymi, przy czym jąderko nie wyróżnia się lub różnicuje słabo. Występują w poszczególnych komórkach najczęściej w liczbie kilku do około trzydziestu (komórki oligokariotyczne), kilkudziesięciu (komórki polikariotyczne), lecz rzadko ponad 100, ale w komórkach zarodnikotwórczych i konidiach rodzajów *Zoophthora* i *Strongwellsea* zawsze pojedynczo, a w konidiach *Massospora* zwykle po 2. Są charakterystyczne dla przedstawicieli rodziny *Entomophthoraceae* ss. B e n-Z e' e v et K e n n e t h.

Ostatnio jednakże w obrębie ostatniego typu jąder wyróżniono dwa podtypy. Pierwszy — o większej ilości nierównomiernie skondensowanej heterochromatyny, tworzącej nieregularne sploty, oraz, w metafazie, o małym wrzecionie kariokinetycznym umiejscowionym ekscentrycznie; typ właściwy większości form z rodziny *Entomophthoraceae* w wyżej sprecyzowanym sensie. Jądra drugiego typu — o małej ilości równomiernie rozmieszczonej heterochromatyny oraz o dużym wrzecionie kariokinetycznym w metafazie, umiejscowionym centralnie i zajmującym ponad połowę objętości komórki — przypisano nowoutworzonej rodzi-

nie *Neozygitaceae* B e n-Z e' e v et K e n n e t h, z jednym rodzajem — *Neozygites*. Ze względów praktycznych układ ten nie będzie w niniejszym opracowaniu stosowany, a rodzaj *Neozygites* pozostawiony jest w rodzinie *Entomophthoraceae*.

Ciała strzępkowe lub poszczególne komórki grzybni strzępkowej mogą funkcjonować jako gametangia, przy czym w niektórych przypadkach komórki te są morfologicznie różne. Zygota powstaje wewnątrz jednego z gametangiów lub uwypukla się na zewnątrz, po czym ulega obłonieniu grubą, dwu- lub trójwarstwową ścianą i funkcjonuje jako zarodnik przetrwalnikowy — zygospora (Fig. 5). U wielu form koniugacja nie następuje, a przetrwalniki są tworzone apogamicznie, jako azygospory, swoją strukturą nie różniące się od zygospor. U niektórych gatunków z rodzaju *Conidiobolus* przekształceniu w zarodniki przetrwalnikowe mogą ulegać również pierwotne lub wtórne konidia przez pogrubienie ściany, któremu towarzyszy zazwyczaj zanik papilli. Jako struktury przetrwalne w grzybni wegetatywnej mogą być tworzone również chlamidospory, zwykle o kształtach kulistych, owalnych lub obło-wydłużonych.

Trzonki konidialne wyrastają bezpośrednio z ciał strzępkowych lub jako odgałęzienia strzępek. Mogą one mieć postać strzępek, częściej jednakże różnią się od nich kształtem, grubością oraz ewentualnie typem rozgałęzień w częściach szczytowych (Fig. 6). U większości gatunków są nierozgałęzione, stanowiąc końcowe odcinki raczej długich strzępek rosnących wewnątrz ciała gospodarza i przebijających jego oskórek, a u saprofitów jako odgałęzienia strzępek wegetatywnych. Ich część szczytowa — stanowiąca komórkę zarodnikotórczą — jest zazwyczaj maczugowato lub butelkowato pogrubiona. U rodzajów *Eryniopsis* i *Zoophthora* (*Entomophthoraceae*) w części szczytowej trzonki konidialne ulegają rozgałęzieniom dichotomicznym lub palczastym, a każde odgałęzienie zakończone jest podobną komórką zarodnikotwórczą. Konidia pierwotne tworzone są terminalnie, po jednym z każdej komórki zarodnikotwórczej. Od tego schematu odbiegają trzonki gatunków z rodziny *Meristacraceae*. U rodzaju *Meristacrum* terminalna część trzonka ulega podziałom błonami poprzecznymi w sukcesji bazypetalnej, tworząc serię położonych liniowo komórek zarodnikotwórczych, a na każdej z nich uwypukla się bocznie jedno drobne konidium. U przedstawicieli rodzaju *Ballocephala* w terminalnej części trzonka nie podzielonego błonami poprzecznymi wyrastają sympodialnie w sukcesji akropetalnej (Fig. 6c) ampułkowate komórki zarodnikotórcze, osadzone w akropleuralnych skupieniach. W rodzaju *Zygnemomyces* konidia powstają na krótkich, sterygmoidalnych wyrostakach bocznych trzonka, nie oddzielonych od niego błonami komórkowymi (Fig. 6a).

Wspólną cechą przedstawicieli owadomorkowych jest aktywne odrzucanie konidiów pierwotnych (Fig. 7c, e-z) dzięki specjalnej strukturze połączenia pomiędzy komórką zarodnikotwórczą a tworzonym konidium; pod działaniem ciśnienia osmotycznego wewnątrz tych komórek dają one efekt analogiczny do zasady działania broni palnej. Wyróżnia się trzy mechanizmy odrzutu konidiów.

1. Zaokrąglenie papilli (rounding off or papilla eversion) — jako najprostszy, a jednocześnie najczęstszy przypadek; polega na silnym wzroście ciśnienia osmotycznego w zarodniku i komórce zarodnikotwórczej, co prowadzi do rozerwania zewnętrznej warstwy błony otaczającej zarówno komórkę jak i uformowany na niej zarodnik oraz uwypuklenia jego cienkobłonnej części nasadowej — zwanej papillą; wskutek tego następuje odrzucenie konidium na pewną odległość.
2. Mechanizm sporonośnej rakiety (sprophore rocket) — obserwowany u gatunków z rodzajów *Basidiobolus* i *Ballocephala*. W odróżnieniu od typu pierwszego oderwanie zarodnika następuje nie w miejscu jego połączenia z komórką zarodnikotwórczą lecz z jej szczytową częścią; zarodnik zostaje przemieszczany siłą odrzutu.
3. Mechanizm wystrzału sporonośnej armatki (sporophore canon) — typowy dla gatunków z rodzaju *Entomophthora* a opisany również dla *Batkoa dysderci*. W okresie dojrzewania konidium silnie zagłębiony w jego nasadowej części szczyt komórki zarodnikotwórczej pod wpływem ciśnienia zostaje rozerwany, a zarodnik odrzucony wraz ze strumieniem płynnej zawartości tej komórki.

Odrzucane aktywnie konidia nazywane są ballosporami. Czasem używany bywa termin „ballistospore", jednakże odnosi się on do specjalnego, ściśle zdefiniowanego typu zarodników, odrzucanych na innej zasadzie. Mechanizmy aktywnego odrzutu konidiów nie funkcjonują tylko u rodzajów *Massospora* i *Zygnemomyces*; taksony te zostały włączone do rzędu owadomorkowych na podstawie podobieństw ontogenezy i przebiegu procesu chorobowego u gospodarzy.

U wszystkich niemal przedstawicieli owadomorkowych została stwierdzona zdolność tworzenia konidiów wtórnych różnego typu (resporulacja) (Fig. 8).

Zarodniki przetrwalnikowe gatunków patogenicznych nie są zdolne do bezpośredniego infekowania właściwych im gospodarzy. Po wykiełkowaniu przetrwalnika wytwarzana jest bądź strzępka rostkowa, na której powstaje jedna lub więcej ballospor, bądź trzonek kapilarny, na którym tworzy się kapilispora.

U kilku entomopatogenicznych gatunków z rodzaju *Conidiobolus* (*Ancylistaceae*) oraz u większości *Entomophthoraceae* stwierdzono występowanie specjalnych strzępek zwanych chwytnikami lub ryzoidami, wyrastającymi z ciała gospodarza po stronie brzusznej w końcowej fazie choroby. Dzięki nim w okresie zarodnikowania grzyba gospodarza, pozostaje przytwierdzany do podłoża, na którym obumiera. Chwytniki te mają postać strzępek stosunkowo grubych i mocnych, niekiedy rozgałęzionych lub zebranych w wiązkowate skupienia (peseudoryzomorfy); końce często mają pogrubione w szerokie, tarczowate przylgi o nierównych i głęboko zatokowych brzegach lub z licznie wyrastającymi nieregularnymi, stosunkowo cienkimi i splecionymi odgałęzieniami, tworzącymi gęstą siateczkę rozpostartą na powierzchni substratu (Fig. 9). Obumierający owad przytwierdzany

jest zwykle w miejscu odwiedzanym przez inne osobniki tego samego gatunku, co ułatwia rozprzestrzenianie się choroby w populacji gospodarza.

U entomopatogenicznych gatunków o palczasto rozgałęzionych trzonkach konidialnych i jednojądrowych konidiach (*Zoophthora*) zwykle występują tzw. pseudocystydy, wyrastające promieniście na grzbietowej części ciała gospodarza, zwykle bezpośrednio przed rozwojem trzonków konidialnych. Mają one postać stożkowato-igiełkowatych, zazwyczaj nierozgałęzionych, niezbyt długich, raczej sztywnych strzępek, wyrastających ponad warstwę zarodnikotwórczą na wysokość od kilkudziesięciu do ponad 300 μm (Fig. 10). U gatunków z rodzaju *Zoophthora* (subg. *Erynia*) są one zazwyczaj kilkakrotnie grubsze od trzonków konidialnych i na szczytach często pogrubione lub nawet z guzami lub krótkimi odgałęzieniami (Fig. 10c, d, e). Przypisuje się im funkcję struktur „przebijających" kutykulę gospodarza dla ułatwienia przerastania wiązek trzonków konidialnych.

Rozwój osobniczy zoopatogenicznych owadomorków przebiega w ogólnych zarysach następująco. Zarodnik przetrwalnikowy (zygospora lub azygospora) w korzystnych warunkach kiełkuje strzępką lub trzonkiem kapilarnym, na których wytwarzane są ballospora albo kapilispora jako jednostki infekcyjne, zdolne — podobnie jak konidia pierwotne — do wtórnej resporulacji. Natrafiwszy na podatnego gospodarza konidia kiełkują, perforując — dzięki wydzielanym enzymom — jego oskórek, a następnie grzybnia opanowuje jamę ciała przez wytwarzanie protoplastów i namnażanie się ciał strzępkowych. Uszkodzenie organów wewnętrznych oraz nagromadzenie matabolitów w płynach ustrojowych gospodarza prowadzi do jego śmierci, po czym następuje rozwój grzybni strzępkowej oraz zarodnikowanie konidialne i przetrwalnikowe, bądź przynajmniej jedna z tych form. Rozwój patogena jest zazwyczaj w pełni zsynchronizowany z rozwojem poszczególnych generacji gospodarza, co prowadzi często do silnej epizoocji.

Rozwój gatunków saprofitycznych jest w zasadzie analogiczny, oczywiście z wyłączeniem fazy infekcji, a dodaniem czynników konkurencji o substraty organiczne z innymi saprofitami. Panuje opinia, że saprofityczne owadomorkowate mogą bytować w różnych środowiskach dzięki bogatym zestawom egzoenzymów, umożliwiających im wykorzystanie substancji organicznych trudno przyswajalnych przez inne mikroorganizmy.

Zależności troficzne. Największą grupę wśród owadomorkowych stanowią patogeny stawonogów, zwłaszcza owadów, lecz infekowane są również nicienie (*Nematoda*) i niesporczaki (*Tardigrada*). Najmniej liczne są patogeny roślin, reprezentowane tylko przez rodzaje *Ancylistes* i *Completoria*, oraz nieliczne gatunki z rodzaju *Conidiobolus*, rozwijające się w owocnikach grzybów wyższych. Niektóre gatunki z rodzaju *Basidiobolus* i *Conidiobolus* powodować mogą również mikozy podskórne zwierząt ciepłokrwistych i człowieka. Większość gatunków z rodzaju *Conidiobolus* traktowana jest jako saprofity, rozwijające się w martwych, częściowo rozłożonych substratach organicznych. W świetle ostatnich ba-

dań — a zwłaszcza wykazania pasożytnictwa tych grzybów w roztoczach (*Acarina*) — można sugerować, że również wśród przedstawicieli tego rodzaju przynajmniej dużą część stanowią gatunki zoopatogeniczne, infekujące drobne stawonogi saprofityczne (mezofaunę).

Jakkolwiek poszczególnym gatunkom owadomorkowych przypisywano na ogół wysoki stopień wybiórczości co do gatunku i stadium rozwojowego gospodarza, to jednak do niedawna przynajmniej kilka gatunków traktowanych było jako polifagiczne („*Entomophthora apiculata*", „*E. sphaerosperma*"). Obecnie można uważać za rzecz udowodnioną, że w naturalnych warunkach poszczególne gatunki owadomorkowych są bądź monofagami bądź oligofagami o raczej bardzo wąskich spektrach zakażanych gospodarzy, zazwyczaj ograniczonych do co najwyżej kilku lub kilkunastu gatunków.

Do niedawna większość owadomorkowych traktowano jako pasożyty obligatoryjne. Postępy w pracach nad hodowlą tych grzybów w kulturach sztucznych umożliwiają dzisiaj pełniejsze rozpoznanie ich wymagań pokarmowych oraz namnażanie w kulturach in vitro. Jednakże większość hodowanych w kulturach szczepów wykazuje postępującą degenerację grzybni wyrażającą się zmianami morfologii, ograniczeniem lub zanikiem zarodnikowania, zmniejszonymi właściwościami infekcyjnymi wobec owadów, a w skrajnych przypadkach zamieraniem kultur. Ponadto części gatunków, zwłaszcza z rodzajów *Entomophaga, Entomophthora, Massospora* i *Neozygites*, nie udało się dotychczas hodować w warunkach in vitro.

Zbiór, hodowla i przechowywanie. Grzyby z rzędu owadomorkowych znaleźć można we wszystkich środowiskach, chociaż zdecydowanie preferowane są przez nie biotopy o stosunkowo wysokiej wilgotności. Tym niemniej znane są gatunki związane ze stanowiskami suchymi (np. *Entomophaga grylli*, *Zoophthora myrmecophaga*, *Conidiobolus gustafssoni* czy *Neozygites fresenii*), a w środowiskach umiarkowanie wilgotnych (lasy świeże, zarośla, uprawy) należą do komponentów pospolitych. Gatunków infekujących owady i większe pajęczaki (*Opiliones*) szukać należy głównie na roślinach zielnych, a w lasach także na podrostach, w silnie zagęszczonych i zróżnicowanych populacjach stawonogów. Okazy zazwyczaj przytwierdzone są do pędów lub liści (najczęściej na ich spodniej stronie) ryzoidami lub przez zwarcie szczęk i zaciśnięcie odnóży na łodygach lub źdźbłach. W pobliżu lustra wody mogą występować — niekiedy masowo — na ziemi, na przybrzeżnych roślinach oraz przedmiotach wystających ponad lustro wody (gałęzie, pnie, pale, kamienie itp.). W koloniach mszyc (*Aphidoidea*), wciornastków (*Thysanoptera*) oraz przędziorków (*Acarina: Tetranychidae*) osobniki zarażone wyróżniają się najczęściej barwą zmumifikowanego ciała, zwykle w krótkim czasie pokrywającego się nalotem trzonków konidialnych. Gatunki infekujące mezofaunę pozyskiwać można w hodowlach in vivo z prób ściółki i gleby o dużej zawartości materii organicznej, oraz z detrytusu podkorowego, dziupli, nor

oraz gniazd ptaków i ssaków. Próby materiału muszą być przeglądane pod mikroskopem stereoskopowym.

Martwe osobniki gospodarzy należy zbierać do plastykowych lub szklanych probówek zamykanych tamponikami z luźnej waty lub perforowanymi korkami. W jednej probówce trzeba umieszczać tylko jeden okaz. Przed poddaniem go dalszej obróbce preparatorskiej należy określić pozycję systematyczną gospodarza. Zarodnikowanie konidialne uzyskuje się łatwo po umieszczeniu okazów w wilgotnych kamerach, najlepiej na czystych szkiełkach nakrywkowych lub przedmiotowych uprzednio odtłuszczonych (np. w acetonie). Dla późniejszej identyfikacji gatunku szczególnie ważne są cechy konidiów pierwotnych, zwłaszcza ich kariologia, rozpoznanie struktury trzonków konidialnych oraz typy konidiów wtórnych. Przy identyfikacji często konieczne jest również określenie cech zarodników przetrwalnikowych.

Wysypane na szkiełku wokół gospodarza konidia utrwalić należy po 1-2 godzinach od momentu rozpoczęcia zarodnikowania, w celu uzyskania preparatów konidiów pierwotnych oraz po kilkunastu godzinach — dla uzyskania konidiów wtórnych. W przypadku gatunków z rodzaju *Zoophthora* (subg. *Zoophthora*) ważne jest uzyskanie kapilispor, które pojawiają się zazwyczaj po okresie kilkunastu do około 30 godzin licząc od momentu umieszczenia okazu w wilgotnej kamerze. Ważnym uzupełnieniem dla prześledzenia rozwoju i morfologii poszczególnych szczepów są preparaty grzybni z wnętrza ciała, wykonywane w różnych fazach procesu chorobowego, oraz struktura ryzoidów. Szybkimi i stosunkowo łatwymi technikami barwienia jąder są sporządzanie preparatów w laktofenolu z acetoorceiną (LPAO) lub barwienie w acetokarminie przed zamknięciem preparatów w glicerożelatynie. Przy użyciu obu wymienionych wyżej barwników jądra ancylistoidalne barwią się słabo lub nie różnicują się w ogóle, więc dla przedstawicieli rodzin *Ancylistaceae* i *Meristacreae* zaleca się stosowanie reakcji Feulgena. Oczywiście, stosowane być mogą również liczne inne techniki barwienia jąder i różnicowania struktur komórkowych.

W celu wyizolowania kultur gatunków patogenicznych zainfekowane osobniki gospodarzy zawieszać można na wieczkach szalek Petriego nad pożywką ale usuwać je po wysypaniu się pierwszych serii zarodników. Innym sposobem jest umieszczanie w wilgotnych kamerach sterylnych szkiełek nakrywkowych tuż ponad zainfekowanymi osobnikami gospodarzy, a po pojawieniu się konidiów na dolnej powierzchni szkiełek inokulowanie nimi pożywek. W obu przypadkach często następuje zakażenie kultur bakteriami lub grzybami saprofitycznymi, dlatego próby izolacji wykonywać należy w miarę możliwości w kilku powtórzeniach, a do pożywek dodawać można antybiotyki (str. 43). Kultury uzyskać można również z zarodników przetrwalnikowych, chociaż na ogół trudno jest określić warunki i czynniki stymulujące ich kiełkowanie. W tym celu — niezależnie od antybiotyków dodawanych do pożywki — należy przeprowadzić odkażanie powierzchniowe prze-

trwalników przez ich przemywanie w roztworze podchlorynu sodu lub sublimatu i płukanie w wysterylizowanej wodzie (str. 42). Podobnie można odkażać powierzchniowo również większe okazy zakażonych i zmumifikowanych gospodarzy, które jednakże po wypłukaniu w wodzie trzeba niezwłocznie osuszyć sterylną ligniną.

Większość gatunków patogenicznych wymaga pożywek dość zróżnicowanych i raczej bogatych w tłuszcze, białko i witaminy Najpowszechniej stosowane jest wzbogacanie pożywek Sabouraud'a żółtkiem ze świeżych jaj kurzych, peptonem, ekstraktem mięsnym, ekstraktem drożdżowym lub mlekiem w proszku (str. 43). Istnieją różne receptury przygotowania takich pożywek, przy czym dla różnych gatunków lub szczepów często zalecane są dodatki innych składników. Nie ma dotychczas uniwersalnej receptury na pożywkę do hodowli wszystkich owadomorkowych. W przypadku wzbogacania pożywki żółtkiem nie może ono być sterylizowane w autoklawie, lecz tylko koagulowane w temperaturze około 80°C przez 15-20 minut. Dla uproszczenia przygotowania takich pożywek autor dodawał żółtko do pożywek schłodzonych po wyjęciu z autoklawu do około 85°C. Antybiotyki dodawać należy do pożywek schłodzonych do temperatury poniżej 50°C.

Izolacja gatunków saprofitycznych — lub za takie dotychczas uważanych — ze ściółki leśnej, gleby lub innych substratów organicznych wymaga również modyfikacji metod, gdyż na ogół ustępują one, zarówno pod względem czasu pojawu jak i tempa wzrostu, typowym saprofitom spośród strzępczaków i workowców. W celu wyizolowania gatunków z rodzaju *Conidiobolus* trzeba na zwilżoną bibułę filtracyjną umieszczoną po dolnej stronie wieczka szalki naprószyć równomiernie próbki badanego substratu oraz przykryć denkiem szalki z pożywką zestaloną. Pojawiające się w ciągu 2-3 tygodni kolonie mogą pochodzić z odrzuconych konidiów owadomorkowych, co jednakże należy sprawdzać bieżąco pod mikroskopem. Podobnie izolować można szczepy *Basidiobolus*, przy czym szczególnie efektywne są substraty pobrane ze środowisk wodnych i błotnych.

Kultury owadomorkowych zachowują na pożywkach żywotność od kilku tygodni do kilkunastu miesięcy w temperaturze pokojowej; dłużej mogą być przechowane w szafkach chłodniczych. Przeszczepianie w okresach 3-6 miesięcznych w zasadzie zapobiega stratom w kolekcjach w wyniku zamierania grzybni. Trzeba jednakże pamiętać, że wielu gatunków tych grzybów nie udało się dotychczas hodować w warunkach in vitro; niekiedy grzybnia rozwijała się skąpo i zamierała szybko po izolacji szczepu. Niektóre jednak szczepy patogeniczne, wstępnie izolowane na pożywki wzbogacone, rozwijają się niekiedy dobrze na standardowych podłożach stosowanych dla saprofitów, np. SDA lub PDA. Tak zachowuje się wiele np. szczepów *Zoophthora* (subg. *Neopandora* i subg. *Zoophthora*, przy czym te drugie wytwarzają, zwłaszcza na PDA, obfite i zazwyczaj bardzo typowe kapilispory).

Ze względu na niewielką ilość zachowanych zbiorów oraz ciągle jeszcze niedostatecznie poznaną morfologię wielu gatunków *Entomophthorales* zebrane materiały powinny być w jak największej ilości zabezpieczone zarówno w postaci preparatów mikroskopowych jak zbiorów zasuszonych lub utrwalonych w płynach konserwujących. Preparaty sporządzone w laktofenolu z różnymi barwnikami (LBCB, LPAB, LPAO) mogą być przechowywane przez dziesięciolecia. Specjalne techniki barwienia i utrwalania preparatów mikroskopowych prowadzą zazwyczaj do dość silnej deformacji struktur, co w przypadkach owadomorkowych może powodować utratę istotnych cech.

Zakażone owady lub zasuszone kultury powinny być przechowywane w probówkach lub pojemniczkach zapobigeających uszkodzeniom struktur grzybniowych na powierzchni, naistotniejszych dla systematyki tych grzybów. Deformacja struktur następuje również pod wpływem niektórych płynów utrwalających, dlatego przechowywanie w stanie suchym wydaje się być korzystniejsze. Ważnym jest, aby przeznaczone do kolekcji okazy w okresie optymalnego rozwoju grzybni i zarodnikowania zostały szybko przesuszone, w celu przerwania zarodnikowania na tym etapie, gdyż w przeciwnym wypadku w kolekcji mogą pozostać tylko konidia wtórne końcowych serii, zupełnie nieprzydatne do charakterystyki morfologicznej i określenia gatunku grzyba (większość zachowanych zbiorów *Entomophthora muscae* z końca XIX i pierwszych lat XX wieku zawiera tylko konidia wtórne).

Zasuszone kolekcje owadomorkowych są szczególnie narażone na zapleśnienie lub zniszczenie przez saprofagi, dlatego konieczne jest utrzymanie w pomieszczeniach niskiej wilgotności oraz regularne dokonywanie okresowych dezynsekcji i przeglądów kontrolnych. Zaleca się przekazywanie zbiorów oraz kultur instytucjom wyspecjalizowanym w zakresie przechowywania zbiorów mikologicznych i kultur mikroorganizmów.

KLUCZE DO OZNACZANIA

Klucz do rodzin

1. Konidiów i konidiotwórczych struktur brak; zarodniki przetrwalnikowe występują (rodzaj formowy) . . . . . *Tarichium*, str. 250
1*. Konidiotwórcze struktury i konidia występują; przetrwalniki występują lub ich brak 2

2. Jądra bazydioboloidalne; strzępki podzielone na jednojądrowe segmenty; trzonki konidialne nierozgałęzione, silnie rozdęte w górnej części; konidia jednojądrowe terminalne, odrzucane wraz ze szczytową częścią trzonka na zasadzie sporonośnej rakiety; niektóre komórki plechy oraz konidia wtórne mogą funkcjonować jako wielozarodnikowe sporangia; gametangia z dziobkowatymi wyrostkami; saprofity, komensale w przewodach pokarmowych żab i jaszczurek, okazyjnie patogeny zwierząt i człowieka . . . . . *Basidiobolaceae*, str. 51
2*. Jądra innego typu; ciała strzępkowe oraz segmenty strzępek zazwyczaj wielojądrowe; gametangia bez dziobków, zarodniki przetrwalnikowe często tworzone apogamicznie; trzonki konidialne nierozgałęzione lub rozgałęzione; komórek funkcjonujących jako wielozarodnikowe sporangia brak 3

3. Jądra entomoftoroidalne; trzonki konidialne nierozgałęzione lub na szczytach rozgałęzione widlasto albo palczasto; konidia pierwotne terminalne, odrzucane na zasadzie zaokrąglenia papilli lub wystrzału; koniugacja izogametangiogamiczna, częste przypadki tworzenia azygospor; pasożyty bezkręgowców — głównie stawonogów, jeden — żyjący w komórkach przedrośli paproci . . . . . *Entomophthoraceae*, str. 93
3*. Jądra ancylistoidalne 4

4. Konidia pierwotne na trzonkach pojedyncze i odrzucane przez uwypuklenie papilli; trzonki konidialne wyjątkowo z odgałęzieniami; saprofity, pasożyty grzybów wyższych, glonów, stawonogów i zwierząt ciepłokrwistych . . . . . *Ancylistaceae*, str. 57
4*. Konidia pierwotne po kilka do kilkudziesięciu, na trzonkach, lateralne lub terminalne w akropetalnej sukcesji i osadzone bocznie na ampułkowatych komórkach zarodnikotwórczych lub sterygmoidalnych wyrostkach, odrzucane aktywnie lub strącane pasywnie; pasożyty nicieni, niesporczaków lub owadów . . . . . *Meristacraceae*, str. 87

Rodzina *Basidiobolaceae*

Rodzaj *Basidiobolus*

Klucz do gatunków

1. Powierzchnia zygospor gładka 2
1*. Powierzchnia zygospor nieregularnie falista 3

2. W kulturach pożywkowych grzybni powietrznej brak, a kolonie niewyraźne, z nielicznymi trzonkami konidialnymi . . . . . *B. haptosporus*, str. 55
2*. Obfita grzybnia w kulturach ze strzępkami powietrznymi i licznymi trzonkami konidialnymi . . . . . *B. meristosporus*, str. 55

3. Mikrokonidia tworzone egzogenicznie z konidiów pierwotnych; kolonie bez zapachu charakterystycznego dla *Streptomyces* . . . . . *B. microsporus*, str. 56
3*. Mikrokonidiów brak; kolonie z wyraźnym zapachem charakterystycznym dla *Streptomyces* . . . . . *B. ranarum*, str. 52

Rodzina *Ancylistaceae*

Klucz do rodzajów

1. Formy lądowe o obfitej grzybni strzępkowej; saprofity, pasożyty stawonogów, rzadziej na grzybach wyższych lub jako patogeny zwierząt ciepłokrwistych i człowieka . . . . . *Conidiobolus*, str. 60
1*. Pasożytnicze formy wodne lub błotne o skąpej, endobiotycznej grzybni; nieliczne strzępki infekcyjne lub trzonki konidialne wyrastające na zewnątrz gospodarzy 2

2. Pasożyty wstężnic (*Desmidiaceae*); strzępki infekcyjne w zetknięciu z powierzchnią wody wytwarzają konidia odrzucane w powietrze . . . . . *Ancylistes*, str. 58
2*. Pasożyty nicieni lub niesporczaków; trzonki konidialne wyrastają z grzybni endobiotycznej w sposób typowy *Macrobiotophthora*, str. 86

Rodzaj *Ancylistes*

Klucz do gatunków

1. Błony gametangiów żeńskich bez guzkowatych wybrzuszeń; odcinki strzępek równowąskie lub zwężone przy przegrodach poprzecznych . 2
1*. Błony gametangiów żeńskich z dużymi guzkowatymi uwypukleniami; odcinki strzępek przewężone w środkowej części oraz słabo zaokrąglone przy przegrodach poprzecznych; konidia kuliste, 22-30 µm; zygospory o średnicy 18.5-22 µm; pasożyt *Closterium* spp. *A. pfeifferi* Beck, str. 60
2. Zygospory o średnicy 14.5-20 µm rozwijają się w wyrostkach gametangiów żeńskich; konidia 13.5-17.5 µm, z wąską papillą do 5 µm długą; pasożyty *Closterium* spp. . . . . *A. closterii*, str. 59
2*. Zygospory o średnicy 25-29.5 µm rozwijają się w mostkach koniugacyjnych; konidia kuliste, 15-25 µm, z papillą stożkowatą; pasożyty *Netrium digitus* . . . . . *A. netrii*, str. 59

Rodzaj *Conidiobolus*

Klucz do podrodzajów

1. Liczne mikrokonidia tworzone są z konidiów pierwotnych lub wtórnych na krótkich trzoneczkach . . . . . *C.* subg. *Delacroixia*, str. 75
1*. Mikrokonidia nie występują; konidia wtórne podobne do pierwotnych tworzone są pojedynczo lub najwyżej po 2-3 2
2. Kapilispory występują . . . . . *C.* subg. *Capillidium*, str. 83
2*. Kapilispory nie występują . . . . . *C.* subg. *Conidiobolus*, str. 62

Podrodzaj *Conidiobolus*

Klucz do gatunków

1. Gatunki entomopatogeniczne wytwarzają ryzoidy na zarażonych owadach 2
1*. Gatunki saprofityczne lub zoopatogeniczne, ale jeśli rozwijają się na owadach, to nie wytwarzają ryzoidów na zarażonych gospodarzach . 4
2. Ryzoidy cienkie, pojedyncze lub co najwyżej luźno splecione, bez tarczowatych przylg lub nieregularnie rozgałęzionych wyrostków na koń-

cach; konidia prawie kuliste, 30-43 x 28-40 mm, z krótką i raczej wąską papillą; na imagines *Culicidae* w chłodnych, wilgotnych środowiskach . . . . . *C. destruens*, str. 65

2*. Ryzoidy silnie splecione w wiązkowate lub spłaszczone pseudoryzomorfy, z nieregularnie rozgałęzionymi wyrostkami na końcach, tworzącymi spłaszczone przylgi; konidia pierwotne kuliste, (32-) 33-39 (-41) µm, z półkulistymi papillami 6-8 x 12-18 µm; nie rozwija się na pożywkach sztucznych; patogen *Ectobius lapponicus* w świetlistych lasach sosnowych . . . . . *C. gustafssoni*, str. 66

3. Gatunki dobrze poznane i scharakteryzowane w kulturach przez K i n g a (1976, 1977) lub prowadzone jego metodyką 4

3*. Gatunki entomopatogeniczne nie hodowane w kulturach lub o niepełnych charakterystykach kultur, uniemożliwiających porównanie z opisami Kinga 21

4. Trzonki konidialne silnie pogrubione, 3-4 razy grubsze od strzępek wegetatywnych 5

4*. Trzonki konidialne nie grubsze lub tylko nie więcej niż dwukrotnie grubsze od strzępek wegetatywnych 6

5. Konidia kuliste, 15-46 x 13-45 µm z papillą 5-17 x 2-6 µm, obłą na szczycie; trzonki konidialne 50-200 x 3-25 µm; chlamidospory 15-46 x 13-40 µm, mogą występować w grzybni substratowej; przetrwalniki nieznane . . . . . *C. adiaeretus*, str. 70

5*. Konidia kuliste lub gruszkowate 20-25 x 12-18 µm z małą, stożkowatą papillą 2-4 x 3-6 µm; trzonki konidialne 100-150 x 13-26 µm; chlamidospor brak; zygospory kuliste, gładkie, 12-18 µm . . . . . *C. bangalorensis*, str. 68

6. Zygospory gładkie lub jeśli szorstkie to bardzo duże, ca 60 µm średnicy, tworzone bocznie w stosunku do podłużnej osi koniugujących odcinków strzępek lub kolonie wytwarzają zapach heksachlorku benzenu; konidia wtórne pasywnie zrzucane nie występują 7

6*. Zygospor brak lub jeśli występują to są szorstkie, o średnicy nie przekraczającej 35 µm i tworzone są wzdłuż podłużnych osi koniugujących segmentów strzępek; pasywnie zrzucane konidia wtórne występują . . . 16

7. Wydłużone konidia wtórne aktywnie odrzucane z trzonków występują; chlamidospory występują lub ich brak 8

7*. Aktywnie odrzucanych wydłużonych konidiów wtórnych brak; chlamidospor brak 9

8. Konidia pierwotne kuliste lub szeroko elipsoidalne, o średnicy 15-54 x 13-45 µm; chlamidospory występują. . . . . *C. eurymitus*, str. 68

8*. Konidia pierwotne owoidalne, 12.5-27 x 10-16 µm, o krótkiej, dość szerokiej papilli; chlamidospor brak . . . . . *C. couchi*, str. 69

9. Konidia pierwotne małe, średnio 19 x 17 µm, nie przekraczają 22x20 µm; trzonki konidialne nie rozdęte 10
9*. Konidia pierwotne większe, średnio 27 x 22 µm, największe 32 x 26 µm, jeśli mniejsze to trzonki konidialne rozdęte 12

10. Zygospory zwykle elipsoidalne, 21-30 x 17-22 µm, tworzone wzdłuż osi koniugujących segmentów strzępek; gametangia wyraźne, powstające z sąsiednich segmentów tej samej strzępki . . . *C. khandalensis*, str. 69
10*. Zygospory zwykle kuliste, 7-18 µm, tworzone wzdłuż osi strzępek lub lateralnie, jeśli większe i elipsoidalne to gametangia nie wyróżniają się 11

11. Trzydniowe kolonie na PDA w twmperaturze 21^0 gęste, nie przezroczyste; zygospory kuliste, gładkie, powstają wzdłuż osi jednej lub obu koniugujących strzępek; gametangia wyraźne . . . . *C. lamprauges*, str. 69
11*. Trzydniowe kultury na PDA w temperaturze 21° rozmyte, przezroczyste; zygospory kuliste, gładkie i szorstkie, tworzone lateralnie na koniugujących strzępkach, lub elipsoidalne, położone osiowo; gametangia niewyraźne . . . . . *C. paulus*, str. 70

12. Zygospory 55-60 µm; strzępki wegetatywne około 15 µm grubości . . . . . *C. utriculosus*, str. 74
12*. Zygospory średnio 40 µm długie; strzępki wegetatywne około 10 µm grubości 13

13. Zygospory gładkie; grzybnia luźna 14
13*. Zygospory szorstkie, jeśli gładkie to grzybnia silnie zwarta przynajmniej w strefach zarodnikowania 15

14. Protoplazma konidiów pierwotnych zawiera w części centralnej zbite; duże globule otoczone drobnogranulkowatą cytoplazmą; ściany zygospor do 3.5 µm grubości . . . . . *C. thromboides*, str. 72
14*. Protoplazma konidiów pierwotnych drobnogranulkowata niekiedy z większymi kulistymi ziarnami równomiernie rozrzuconymi wewnątrz zarodnika; ściany zygospor do 5.5 µm grubości . . . *C. megalotocus*, str. 71
podrodz. *Delacroixia*

15. Zygospory szorstkie, ale pojedyncze gładkie mogą też występować; kolonie często o zapachu heksachlorku benzenu; grzybnia dość luźna . . . . . *C. osmodes*, str. 71
15*. Zygospory gładkie; kultury bez wyraźnego zapachu; grzybnia zwarta przynajmniej w strefach zarodnikowania . . . . *C. stromoideus*, str. 72

16. Szczeciniaste przetrwalniki są tworzone . . . . . *C. coronatus*, str. 78
podrodz. *Delacroixia*

16*. Przetrwalniki szczeciniaste (owłosione) nie są tworzone 17

17. Chlamidospory występują; zygospor brak . . . . . .

17*. Chlamidospor brak lub pojawiają się w bardzo starych, ponad 1-miesięcznych kulturach; zygospory — jeśli występują — gładkie 20

18. Chlamidospory kuliste; długość trzonków konidialnych poniżej 100 µm . . . . . *C. lachnodes*, str. 71

18*. Chlamidospory wydłużone o dość zmiennych kształtach; trzonki konidialne ponad 100 µm długości 19

19. Chlamidospory kuliste lub beczułkowate; długość trzonków konidialnych zmienna, lecz powyżej 200 µm. . . . . *C. firmipilleus*, str. 79
podrodz. *Delacroixia*

19*. Chlamidospory duże, ca 45 µm długości, o zmiennych kształtach; długość trzonków konidialnych mniej zróżnicowana . . . . . .
. . . . . *C. multivagus*, str. 73

20. Trzonki konidialne grubością równe strzępkom lub tylko nieznacznie grubsze; protoplazma pozostająca w trzonku po odrzuceniu konidium tworzy nadal funkcjonującą komórkę . . . . . *C. firmipilleus*, str. 79
podrodz. *Delacroixia*

20*. Przynajmniej część trzonków konidialnych wyraźnie grubsza od strzępek; chlamidospor brak; resztki protoplazmy nie zachowują żywotności komórki po odrzuceniu konidium . . . . . *C. megalotocus*, str. 81
podrodz. *Delacroixia*

21. Grzyb nie hodowany w kulturach pożywkowych, morfologia znana tylko z okazów zarażonych stawonogów; konidia pierwotne o średnicy 34-45 µm, ze stożkowatą papillą zaostrzoną na szczycie 7-14 x 8.5-15.5 µm; na roztoczu *Pergamasus* sp . . . . . *C. chlapowskii*, str. 75

21*. Grzyb hodowany również w kulturach pożywkowych; konidia pierwotne o średnicy 28-35 µm, z półkuliście uwypukloną, obłą papillą; na mszycach . . . . . *C. obscurus*, str. 73

Podrodzaj *Delacroixia*

Klucz do gatunków

1. Cechy kultur dobrze scharakteryzowane na PDA; grzyby uważane za saprofityczne lub słabo zoopatogeniczne 2
1*. Cechy kultur na PDA niewystarczająco scharakteryzowane; grzyb entomopatogeniczny tworzący wiązkowate ryzoidy na zakażonych owadach; konidia gruszkowate 24-31.5 x 20-25 µm, z ostro uwypukloną papillą 7-11.5 x 7-11.5 µm; na czerwcach *Pseudococcus calceolariae* . . . . . *C. pseudococci*, str. 82

2. Grzybnia strzępkowa, rozgałęziona, strzępki przynajmniej w brzeżnych strefach kolonii nie segmentowane; zarówno strzępki jak i ich segmenty mniej więcej równowąskie, kilkadziesiąt do kilkuset µm długie, tylko w centralnych partiach kolonii septowanie gęściejsze, niekiedy z wyróżnialnymi kulistymi lub wydłużonymi chlamidosporami 3
2*. Strzępki nawet w najwcześniejszych fazach wzrostu nieregularnie septowane, tworzące różnokształtne lub niezupełnie kuliste ciała strzępkowe; kolonie małe, nieprzezroczyste, drożdżopodobne, barwy jasnobrunatnej; trzonki konidialne w górnych częściach nie pogrubione; papille konidiów pierwotnych silnie uwypuklone, na końcach tępe; zygospory kuliste 20-36 µm, o błonach 0.5-1.5 µm grubości . . . . . *C. mycophilus*, str. 81

3. Wzrost na PDA stosunkowo szybki — w temperaturze 21°C trzydniowe kolonie osiągają średnicę 30 mm lub więcej, a jeśli kolonie mniejsze, to w grzybni występują kuliste chlamidospory 4
3*. Wzrost na PDA powolny: trzydniowe kolonie przy temperaturze 21°C nie przekraczają 25 mm średnicy 8

4. Chlamidospory w grzybni substratowej, zwłaszcza w starszych strefach kolonii; papille konidiów pierwotnych zaostrzone 5
4*. Chlamidospor brak 6

5. Kolonie wełniste na przezroczystym tle, złożone z długich, segmentowanych strzępek o grubości 2-20 µm; chlamidospory nieregularnie kuliste lub beczułkowate, 15-50 x 8-48 µm, u niektórych szczepów nie występują; wymiary konidiów pierwotnych silnie zróżnicowane, 8-50 x 6.5-44 µm; zygospory nieznane . . . . . *C. firmipilleus*, str. 79
5*. Powierzchnia kolonii przezroczysta, strzępki krótko segmentowane o grubości 7-10 µm; kuliste chlamidospory w starszych strefach kolonii; konidia kulistawe lub gruszkowate 26-38 x 23-34 µm; zygospory kuliste, 7-20 µm, lub wydłużone, do 35 µm długie . . . . *C. humicolus*, str. 80

6. Kolonie początkowo białe, później brunatnawe, o prószystej powierzchni; trzonki konidialne w srodkowej części nieco rozdęte, 30-210 x 9,5-25 µm; szczeciniaste przetrwalniki zwykle występują; zygospory nieznane . . . . . *C. coronatus*, str. 78

6*. Kolonie o powierzchni jedwabistej lub aksamitnej bez brunatnego odcienia; sczeciniastych, przetrwalników brak 7

7. Trzonki konidialne o grubości równej strzępkom lub nieznacznie grubsze; konidia pierwotne gruszkowate lub szeroko elipsoidalne, 25-54 x 30-50 µm o papillach obłych, dość szerokich i silnie wystających, 8-23 x 6-15 µm . . . . . *C. macrosporus*, str. 80

7*. Trzonki konidialne wyraźnie grubsze od strzępek wegetatywnych, jeśli słabo pogrubione, to papille konidiów pierwotnych zaostrzone na końcach; konidia pierwotne kuliste o mniejszych papillach; przy koniugacji tworzą się plemniopodobne zgrubienia . . . . . *C. megalotocus*, str. 81

8. Konidia pierwotne kulistawe, 14-29 x 12-25 µm, z ostro uwypukloną, stożkowatą papillą 4-7,5 x 2-6 µm; trzonki konidialne krótkie, 20-30 x 5-12 µm; zygospory nieznane. . . . . *C. polytocus*, str. 82

8*. Konidia pierwotne kuliste do gruszkowatych, większe — do około 40 µm — i o większym zakresie zmienności; zygospory występują 9

9. Kolonie gęste, nieprzezroczyste; segmenty strzępek w starszych strefach kolonii, 6-25 µm grubości; konidia pierwotne 12-42 x 11-37 µm, o papillach stożkowatych, 2-12 µm długich i 2-9 µm szerokich przy nasadzie; mikrokonidia prawie kuliste lub krótko elipsoidalne, 8-16 x 5,5-11 µm; trzonki konidialne 20-130 µm . . . . . *C. incongruus*, str. 79

9*. Kolonie zbite, nieprzezroczyste z gęstą grzybnią powietrzną; segmenty strzępek w starszych strefach kolonii 6-25 µm grubości; konidia pierwotne 12-42 x 11-37 µm, z dość długimi, zaostrzonymi papillami 2-12 x 2-9 µm; mikrokonidia owoidalne, 12,5-17 x 10.5-15.5 µm; trzonki konidialne 15-50 x 6-10 µm . . . . . *C. brefeldianus*, str. 78

Podrodzaj *Capillidium*

Klucz do gatunków

1. Wzrost na PDA powolny — trzydniowe kolonie osiągają przy temperaturze 21°C ca 10-15 µm średnicy; zygospory nie występują 2

1*. Średnica trzydniowych kolonii na PDA przy temperaturze 21° przekracza 20 mm; zygospory zwykle występują 3

2. Grzybnia zwarta z licznymi płatowatymi lub rozszerzającymi się ku końcom odgałęzieniami strzępek; konidia pierwotne kuliste, 21-26 x 20-24 µm, z małą stożkowatą papillą, na szczycie zaokrągloną . . . . . *C. lobatus*, str. 84

2*. Grzybnia bez płatowych odgałęzień; konidia pierwotne kulistawe lub odwrotnie stożkowate, 9-32 x 6-25 µm, z dość długą, zaostrzoną papillą . . . . . *C. pumilus*, str. 85

3. Trzonki konidialne wyraźnie rozszerzające się ku szczytowi; konidia pierwotne kuliste, 22-36 x 18-30 µm, z szeroko zaokrągloną papillą; zygospory kuliste 13-31 µm o ścianie żółtawej, 1-2.5 µm grubości . . . . . *C. rhysosporus*, str. 85

3*. Trzonki konidialne nie poszarzające się ku szczytowi w sposób wyraźny; konidia pierwotne kuliste, 10-35 x 9-30 µm, ze stożkowatą papillą zaokrągloną na samym szczycie; zygospory kuliste, wydłużone lub nieregularne o średnicy 7-18 µm, o błonie bezbarwnej lub blado-żółtawej, 0.8-2 µm grubej, czasem ich brak . . . . *C. heterosporus*, str. 84

Rodzaj *Macrobiotophthora*

Klucz do gatunków

1. Plecha wegetatywna składa się z ciał strzępkowych; przetrwalniki nieznane; pasożyt niesporczaków (*Tardigrada*) . . *M. vimariensis*, str. 87

1*. Plecha wegetatywna złożona z nieseptowanych strzępek; przetrwalniki 12-ścienne o średnicy ca. 20 µm; pasożyt nicieni . . . . . *M. vermicola*, str. 87

Rodzina *Meristacraceae*

Klucz do rodzajów

1. Trzonki konidialne bez bocznie osadzonych ampułkowatych komórek zarodnikotwórczych, w części szczytowej dzielące się poprzecznymi ścianami linearnie; konidia pierwotne gruszkowate, tworzone bocznie i pojedynczo z każdej komórki, odrzucane przez uwypuklenie papilli (papilla eversion); pasożyty nicieni i owadów . . . . *Meristacrum*, str. 88

1*. Trzonki konidialne nie podzielone błonami poprzecznymi; komórki zarodnikotwórcze lub wyrostki zarodnikonośne wyrastają sympodialnie 2

2. Na trzonkach liczne ampułkowate komórki zarodnikotwórcze osadzone

akropleurogenicznie i oddzielone od trzonka ścianą komórkową; zarodniki odrzucane na zasdzie „sporonośnej rakiety"; pasożyty niesporczaków . . . . . *Ballocephala*, str. 90

2*. Na trzonkach nieliczne, stożkowate lub haczykowate wyrostki zarodnikonośne nie oddzielone ścianą od osi trzonka; konidia zrzucane pasywnie; pasożyty nicieni . . . . . *Zygnemomyces*, str. 92

Rodzaj *Ballocephala*

Klucz do gatunków

1. Komórki zarodnikotwórcze nie rozdęte, mniejsze od konidiów, zebrane w wyraźne przyszczytowe skupienia. . . . . *B. pedicellata*, str. 91

1*. Komórki zarodnikotwórcze pęcherzykowate, tak duże jak konidia lub większe, osadzone na znacznej długości trzonka konidialnego 2

2. Powierzchnia zarodników gładka, nieornamentowana . . . . . *B. sphaerosperma*, str. 91

2*. Powierzchnia zarodników brodawkowana . . *B. verrucospora*, str. 91

Rodzaj *Meristacrum*

Klucz do gatunków

1. Trzonki konidialne często słabo spiralnie wygięte; konidia pierwotne owoidalne po 2-15 na trzonku; konidia wtórne zrzucane pasywnie; azygospory kuliste o powierzchni falisto dołkowatej; pasożyt nicieni . . . . . *M. asterospermum*, str. 89

1*. Trzonki wyprostowane lub słabo wygięte; konidia pierwotne gruszkowate, z wąską, brodaweczkowatą papillą; konidia wtórne podobne do pierwotnych; zygospory owoidalne o powierzchni punktowanej; pasożyt w larwach ślepaków (*Tabanidae*) . . . . . *M. milkoi*, str. 90

Rodzaj *Zygnemomyces*

Klucz do gatunków

1. Wyrostki zarodnikonośne tworzą ostre kąty z dystalną częścią trzonka konidialnego, którego szczyt jest prosty; zarodniki liczne . . . . . *Z. echinulatus*, str. 92

1*. Wyrostki zarodnikonośne odgięte ku nasadzie trzonka, tworzą z jego częścią dystalną kąty rozwarte, również szczyt trzonka hakowato odgięty; zarodniki nieliczne . . . . . *Z. pendulatus*, str. 93

Rodzina *Entomophthoraceae* — owadomorkowate

Klucz do rodzajów

1. Ściany konidiów jednowarstwowe (dwuwarstwowość może być wykryta pod mikroskopem elektronowym); konidia pierwotne dwu-, kilku- lub wielojądrowe 2
1*. Ściany konidiów dwuwarstwowe z wyjątkiem uwypuklenia papillarnego, dwuwarstwowość widoczna pod zwykłym mikroskopem optycznym; konidia pierwotne jednojądrowe 9
2. Trzonki konidialne w części szczytowej rozwidlone lub skąpo rozgałęziające się monopodialnie, często przemieszane z nierozgałęzionymi; konidia owoidalne lub wydłużone. . . . . *Eryniopsis*, str. 130
2*. Trzonki konidialne nierozgałęzione, zupełnie wyjątkowo rozwidlające się w pobliżu nasady 3
3. Gatunki fitopatogeniczne; plechy rozwijają się w postaci ciał strzępkowych wypełniających komórki przedrośli paproci *Completoria*, str. 112
3*. Gatunki zoopatogeniczne — grzybnia rowzwija się w jamie ciała bezkręgowców w postaci protoplastów, ciał strzępkowych lub strzępek, powodując zniszczenie poszczególnych tkanek lub organów i wyrastając na zewnątrz zazwyczaj po śmierci gospodarzy lub nieco wcześniej . . . 4
4. Patogeny nicieni i niesporczaków . . . . *Macrobiotophthora*, str. 86 rodzina *Ancylistaceae*
4*. Patogeny stawonogów, głównie owadów i pajęczaków 5
5. Zarodnikowanie konidialne przebiega wewnątrz gospdarzy pod ich szkieletem; konidia dwujądrowe (pojedyncze wyjątkowo z 1 lub 3 jądrami), pasywnie odrywające się od trzonków, powierzchnia konidiów często szorstka lub z delikatną ornamentacją; patogeny cykad żyjących skupiskowo . . . . . *Massospora*, str. 145
5*. Zarodnikowanie konidialne na powierzchni ciała gospodarzy; konidia o gładkiej błonie pokrytej lepką substancją, odrzucane z trzonków aktywnie 6
6. Jądra barwią się jednolicie (bez ciemniejszych splotów lub nici heterochromatynowych); zygospory ciemnozabarwione dwujądrowe, zwykle

jajowate, ellipsoidalne lub kulistawe, powstające z kanałów kopulacyjnych pomiędzy dwoma oligokariotycznymi ciałami strzępkowymi; konidia typowo cztero- lub ośmiojądrowe z możliwymi niewielkimi odchyłkami liczby jąder, o prosto ściętej lub bardzo słabo uwypuklonej papilli, lecz nigdy typu „*truncata-campaniformis*", i zazwyczaj o ściemniałej („przydymionej") ściance; kapilispory występują *Neozygites*, str. 133

6*. Jądra barwią się nierównomiernie, z widocznymi ciemniejszymi nićmi i splotami heterochromatynowymi; zygospory o różnej liczbie jąder, kuliste lub jajowate, tworzone z macierzystego gametangium lub jego wyrostka; często znane są tylko azygospory; konidia od dwu- do wielojądrowych, jeśli liczba jąder 4-8, to konidia typu „*truncata-campaniformis*"; kapilispory nie występują 7

7. Konidia pierwotne typu „*truncata-campaniformis*", zawierają od 2 do ca 30 jąder; konidia wtórne tego samego typu . . *Entomophthora*, str. 95

7*. Konidia pierwotne kuliste z dużymi, wyraźnie uwypuklonymi papillami, lub gruszkowate, zawierające od kilkunastu do kilkudziesięciu jąder; konidia wtórne podobne lub silnie wydłużone 8

8. Konidia pierwotne kuliste z mocno kopulasto uwydatniającą się papillą, często opatrzoną kolcowatym wyrostkiem w środku wypukłości; trzonki konidialne rozdęte, w szczytowej części łagodnie butelkowato przewężone w długą szyjkę; ryzoidy — jeśli występują — zakończone tarczowatymi przylgami . . . . . *Batkoa*, str. 106

8*. Konidia pierwotne gruszkowate, łagodnie przewężające się ku nasadzie zamkniętej uwypukloną papillą bez kolcowatego wyrostka w środku; trzonki konidialne maczugowate bez szyjkowatego przewężenia lub tylko z bardzo krótkim kołnierzykowatym zwężeniem; ryzoidów brak . . . . . *Entomophaga*, str. 113

9. Trzonki konidialne nierozgałęzione; zarodnikowanie w kulistych kapsułach wewnątrz odwłoka gospodarza, otwartych od strony sternalnej; ryzoidów brak . . . . . *Strongwellsea*, str. 143

9*. Trzonki konidialne w szczytowej części zazwyczaj obficie dychotomicznie lub palczasto rozgałęzione, zarodnikowanie na powierzchni gospodarza; ryzoidy niemal zawsze występują . . . . . *Zoophthora*, str. 147

Rodzaj *Entomophthora*

Klucz do gatunków

1. Zarodnikowanie konidialne rozpoczyna się na jeszcze żywych gospodarzach; ryzoidy nie występują 2
1*. Zarodnikowanie konidialne rozpoczyna się po śmierci gospodarza; ryzoidy występują lub nie, niekiedy trudno zauważalne 3

2. Patogen larw wielbłądek (*Raphidia ophiopsis*). . . . *E. weberi*, str. 106
2*. Patogen pluskwiaków różnoskrzydłych, *Adelphocoris* sp. (*Miridae*) oraz skoczków (*Auchenorrhyncha*) . . . . . *E. erupta*, str. 100
2. Patogen wciornastków, *Thrips tabaci (Thripidae)* *E. thripidum*, str. 105

3. Patogeny muchówek 4
3*. Patogeny innych owadów 10

4. Patogeny muchówek krótkoczułkowatych głównie z grupy *Cyclorrhapha*; rozwój ryzoidów ograniczony tylko do narządów gębowych (ssawki); konidia pierwotne zawierają 5 do około 25 jąder 5
4*. Patogeny muchówek długoczułkowych (*Nematocera*); ryzoidy wyrastają z narządów gębowych lub różnych części sternalnej strony ciała, jeśli ryzoidy tylko w obrębie narządów gębowych, to konidia zawierają 2-5, najczęściej 3 jądra 6

5. Konidia pierwotne 16-25 x 12-22 µm, zawierają zazwyczaj (3)-4-7 jądra o średnicy 5-7 µm; głównie na muchówkach z rodziny *Anthomyidae* . . . . . *E. schizophorae*, str. 103
5*. Konidia pierwotne, 21-36 x 16-30 µm, zawierają zazwyczaj 10-30 jąder o średnicy 3-4 µm; 6

6. Na muchówkach z grupy *Calyptrata*, głównie z rodzin *Muscidae* i *Calliphoridae*; konidia pierwotne (6-) 10-22 (-30)-jądrowe *E. muscae*, str. 97
6*. Na muchówkach z rodziny *Scatophagidae*; konidia pierwotne 12-19 — jądrowe . . . . . *E. scatophagae*, str. 103
6***. Na mszycznikach (*Syrphidae*); konidia pierwotne 27-31 x 22-24.5 um, 16-24-jądrowe; papilla 12-14 µm szeroka. . . . . *E. syrphi*, str. 104

7. Konidia pierwotne 10-22 x 8-19 µm, zazwyczaj z 4-10, wyjątkowo 3 lub 11-13, jądrami o średnicy ca 3 um; na imagines *Cecidomyidae* . . . . . *E. brevinucleata*, str. 98
7*. Konidia pierwotne podobnej wielkości, ale z 1-5 większymi jądrami . 8

8. Konidia pierwotne 12-15 x 8-11 µm, zazwyczaj z 2(-3) jądrami; liczne

ryzoidy wyrastają na całej spodniej stronie ciała; na imagines *Culicidae* i *Chironomidae* obumierających tuż nad powierzchnią wody . . . . . *E. culicis*, str. 99

8*. Konidia pierwotne nieco większe, 1-5 jądrowe 9

9. Konidia pierwotne 15-19 x 11-16 µm z 3-4 (-5), jądra o średnicy 3-4 µm; ryzoidy wyrastają poprzez narządy gębowe oraz z końcowego segmentu odwłoka; na imagines *Cecidomyidae* . . . . . *E. israelensis*, str. 102

9*. Konidia pierwotne 16-22 x 12-18 µm, z 3, rzadko 2 lub 4-5, jądra o średnicy 5-6.5 µm; ryzoidy tylko w okolicy narządów gębowych, niekiedy trudno zauważalne; na imagines *Sciaridae* . . . *E. trinucleata*, str. 105

10. Ryzoidy występują tworząc często splot w odwłokowej części ciała; konidia pierwotne 15-23 x 11-19 µm, 4-11 jądrowe; na mszycach . . . . *E. planchoniana*, str. 102

10*. Ryzoidów brak, konidia pierwotne 16-24 x 12-19 µm, 6-18-jądrowe; na pluskwiaku *Notostira elongata* (*Miridae*) . . . . . *E. helvetica*, str. 100

Rodzaj *Batkoa*

Klucz do gatunków

1. Ryzoidy występują; papille konidiów pierwotnych często z małym, delikatnym kolcem w środku uwypuklenia 2

1*. Ryzoidów brak; papille zwykle bez kolca 4

2. Konidia pierwotne gruszkowate, 47-52 x 32.5-35.5 µm, od połowy długości ku nasadzie zwężone w stosunkowo grubą ponadpapillarną szyjkę, zakończoną mocno wypukłą papillą . . . . . *B. papillata*, str. 112

2*. Konidia pierwotne niemal regularnie kuliste, ponadpapillarna szyjka — jeśli występuje — bardzo krótka 3

3. Konidia pierwotne z papillą 30-38 x 29-34 µm . . *B. apiculata*, str. 107

3*. Konidia pierwotne z papillą 48-52 (-57) x 40-47 µm . *B. major*, str. 110

4. Konidia pierwotne, o średnicy 80-99 µm, zawierają ponad 50 jąder; na imagines *Tipulidae* . . . . . *B. gigantea*, str. 109

4*. Konidia pierwotne z papillą 35-46 x 30-40 µm, 17-20-jądrowe; na pluskwiakach *Dysdereus* spp. (*Heteroptera*: *Pyrrhocoridae*) . . . . . *B. dysderci*, str. 109

Rodzaj *Completoria*

Jeden gatunek . . . . . *C. complens*, str. 113

Rodzaj *Entomophaga*

Klucz do gatunków

1. Konidia pierwotne małe, 15-31 x 12-25 µm; przetrwalniki o średnicy 12-25 µm 2
1*. Konidia pierwotne wyraźnie większe, najmniejsze ponad 25 µm długości; przetrwalniki znacznie większe lub nieznane 3

2. Konidia pierwotne owoidalne, 17-18 x 12-14 µm; zarodniki przetrwalnikowe prawie kuliste, o średnicy około 21 µm; na gąsienicach motyli . . . . . *E. saccharina*, str. 123
2*. Konidia pierwotne gruszkowate, 15-31 x 12-25 µm, z wyraźnym ponadpapilarnym zwężeniem; na mszycach . . . . . *E. pyriformis*, str. 119

3. Patogen kosarzy (*Arachnoidea: Opiliones*); konidia pierwotne ca 43-52 x 30-37 µm . . . . . *E. batkoi*, str. 128
3*. Patogeny owadów 4

4. Na dorosłych muchówkach (*Diptera*) 5
4*. Na innych owadach 8

5. Zarodnikowanie konidialne przebiega na żywych owadach; często obserwuje się odpadanie segmentów odwłoka; na muchówkach z grupy *Calyptrata* . . . . . *E. kansana*, str. 119
5*. Zarodnikowanie konidialne na martwych owadach; segmenty odwłoka niekiedy rozrywane wzdłuż szwów poprzecznych ale nie odpadają . 6

6. Na ślepakach (*Tabanidae*); konidia pierwotne 36.7±3.5 x 32.4±3.2 µm, zwykle około 15-jądrowe . . . . . *E. tabanivora*, str. 125
6*. Na muchówkach długoczułkowych (*Nematocera*) 7

7. Konidia pierwotne (30-) 41-48 (-61) x (21-) 30-34 (-46) µm, 11-36-jądrowe; występują tylko konidia wtórne typu ballospor podobnych do konidiów pierwotnych; na małych muchówkach na powierzchni wody lub tuż nad wodą . . . . . *E. conglomerata*, str. 119
7*. Konidia pierwotne 36-43 (-47) x 23-26 (-27) µm, 8-28-jądrowe; zwykle występują ballospory wtórne oraz wydłużone konidia wtórne; na imagines *Tipulidae* i *Limoniidae* w liściastych podrostach leśnych . . . . . *E. tipulae*, str. 123

8. Konidia pierwotne 12-18-jądrowe, jajowate lub stożkowato zwężone ku nasadzie, 35-43 x 24-30 µm, o wąskich papillach, nie szerszych niż 1/3 maksymalnej grubości konidium; na chrząszczach *Lagria hirta* . . . . . *E. lagriae*, str. 121
8*. Konidia pierwotne gruszkowate, zawierają od kilkunastu do kilkudziesię-

ciu jąder, szerokość papilli zwykle równa około połowie grubości konidium; na innych owadach 9

9. Konidia pierwotne 27-40 (-47.5) x (18-) 20-35 (-40) µm; zarodniki przetrwalnikowe kuliste o żółtym lub brunatnym episporium, ich średnica 30-45 µm; na prostoskrzydłych (*Orthoptera*) lub gąsienicach motyli (*Lepidoptera*) 10

9*. Konidia pierwotne większe, 40-56 x 35-43 µm; zarodniki przetrwalnikowe bezbarwne, zwykle o średnicy ponad 50 µm; na larwach liściarek (*Tenthredinidae*), wyjątkowo także na imagines 13

10. Na gąsienicach motyli; ciała strzępkowe okrągłe lub nieregularne, wydłużone 11

10*. Na szarańczakach (*Orthoptera*); ciała strzępkowe kuliste, owoidalne lub o mniej regularnych, zaokrąglonych kształtach 12

11. Konidia pierwotne 10-15-jądrowe, (24-) 29.5-32.5 (-44) x (17-) 20-22 (-30) µm, lub o zbliżonych wymiarach . . . . . *E. aulicae*, str. 117 (gatunek zbiorowy)

11*. Konidia pierwotne 21-34-jądrowe, średnio 26-jądrowe, 20-36 x 16-28 µm; na gąsienicach *Lymantria dispar* L. . . . . *E. maimaiga*, str. 118

12. Patogeny *Melanoplus* spp., tworzące skąpo zarodnikowanie konidialne . . . . . *E. calopteni*, str. 117

12*. Patogeny innych gatunków, łatwo i obficie tworzące konidia . . . . . *E. grylli*, str. 116 (gatunek zbiorowy)

13. Zarodniki przetrwalnikowe regularnie kuliste, 45-60 (-66) µm, o ścianie 2.5-3 µm grubości; na larwach *Tenthredinidae* na roślinach zielnych i krzewach liściastych . . . . . *E. tenthredinis*, str. 126

13*. Zarodniki przetrwalnikowe zwykle nieregularnie kuliste, 45-75 (-90), jajowate lub elipsoidalne, 50-85 x 45-65 µm, o ścianie 5.5-7.5 µm grubej, często z zaznaczonymi nasadowymi uwypukleniami; na larwach *Diprion simile* w kokonach, na drzewach iglastych . . . . *E. diprionis*, str. 126

Rodzaj *Eryniopsis*

Klucz do gatunków

1. Konidia pierwotne jajowate, 30-35 x 14-20 µm; kapilikonidia występują; na chrząszczach *Chauliognathus pennsylvanicus* . . . . . *E. lampyridarum*, str. 131

1*. Konidia pierwotne silnie wydłużone, cylindryczne, wąsko wrzecionowate lub ku nasadom zwężające się; kapilikonidiów brak; na muchówkach długoczułkowych (*Diptera: Nematocera*) w mokrych biotopach . . 2

2. Konidia pierwotne o końcach obłych, cylindryczne lub słabo zwężone w części nasadowej, 22-51 x 11-19 µm z niewyraźną papillą; konidia wtórne owoidalne lub wrzecionowate; ryzoidów brak; na imagines *Tipulidae* . . . . . *E. caroliniana*, str. 131

2*. Konidia pierwotne smukłe, wąsko wrzecionowate o stożkowatym szczycie, zwykle zgięte, 45-75 x 8-10 µm; papille wąskie o zarysie trójkątnym; ryzoidy pojedyncze, bez rozszerzonych przylg; na imagines *Chironomidae, Tipulidae* i pokrewnych muchówek . . . . *E. longispora*, str. 133

Rodzaj *Neozygites*

Klucz do gatunków

1. Patogeny drobnych owadów roślinożernych o ssącym typie narządów gębowych (mszyce, wciornastki i czerwce) 2

1*. Patogeny roztoczy (*Acarina*) 9

2. Długość konidiów pierwotnych nie przekracza 18 µm; na wciornastkach (*Thripidae*) lub na czerwcach (*Coccoidea*) 3

2*. Długość konidiów pierwotnych zazwyczaj 20-36 µm; patogeny mszyc 6

3. Ciała strzępkowe kuliste lub subsferoidalne; patogeny czerwców (*Coccoidea*) 4

3*. Ciała strzępkowe wydłużone, cylindryczne lub maczugowate; patogeny wciornastków (*Thysanoptera*) 5

4. Konidia pierwotne jajowate, 18 x 9-10 µm przetrwalniki nieznane; na *Lecanium viride* . . . . . *N. lecanii*, str. 139

4*. Konidia pierwotne kuliste, 11-16 x 9-13 µm; przetrwalniki kuliste, 12.5-17.5 µm średnicy; na *Phenacoccus spp.* . . . . . *N. fumosa*, str. 139

5. Kapilikonidia migdałokształtne, 12-21 x 5.5-10 µm, o proporcji L:D około 2; kapilifory cienkie, 60-120 µm długie; przetrwalniki kuliste o średnicy 15-20,5 µm, o powierzchni falistolinijnej pomarszczonej; na *Thrips* spp. . . . . *N. parvispora*, str. 140

5*. Kapilikonidia wydłużone, kształtu ogórka, (22.5-) 25-30 (-32) x (7.5-) 8-9.5 (-11) µm, o proporcjach L:D zwykle około 3; kapilifory grubsze, (16-) 20-30 (-40) µm długie; przetrwalniki o średnicy (19-) 20-23 (-26,5)

µm, o powierzchni nierówno brodaweczkowanej; na *Drepanothrips reuteri*. . . . . *N. cucumeriformis*, str. 140

6. Konidia pierwotne odwrotnie stożkowate lub gruszkowate o papilli wyraźnie wypukłej, 7-11-jądrowe; na mszycach z rodziny *Lachnidae* . . . . . *N. turbinata*, str. 137

6*. Konidia pierwotne o papilli ściętej, zazwyczaj 4-5-jądrowe, wyjątkowo 3- lub 6-jądrowe mogą być spotykane; na mszycach z rodziny *Aphididae* 7

7. Konidia pierwotne o kształcie odwrotnie butelkowatym lub jajowatym, 35-38 x 20-30 µm; zarodniki przetrwalnikowe nieznane . . . . . *N. lageniformis*, str. 136

7*. Konidia pierwotne wyraźnie mniejsze, 18-26 x 14-19 µm; zarodniki przetrwalnikowe elipsoidalne 8

8. Konidia pierwotne 18-22 x 14-18 um, zazwyczaj 4-jądrowe, wyjątkowo o 3 lub 5 jądrach; kapilikonidia, 20-27 x 11-14 µm, na kapiliforach zwykle nie dłuższych niż 60 µm; ciała strzępkowe 4-jądrowe . . . . . *N. fresenii*, str. 136

8*. Konidia pierwotne w większości 5-jądrowe 24-26 x 18-19 µm; kapilikonidia 30-34 x 12-15 µm, na kapiliforach zwykle ponad 100 µm długich; ciała strzępkowe 4- oraz około 8-jądrowe . . . *N. microlophii*, str. 137

9. Konidia pierwotne 12-22.5 x 13-17.5 µm; kapilikonidia nieznane; zarodniki przetrwalnikowe kuliste, 14-18 µm, na powierzchni brodawkowane; na *Macrocheles peregrinus* . . . . . *N. acaridis*, str. 142

9*. Konidia pierwotne 12-18 x 10-15 µm; kapilikonidia występują; zarodniki przetrwalnikowe zwykle szeroko elipsoidalne lub prawie kuliste; na przędziorkach (*Tetranychidae*) 10

10. Kapilikonidia wysmukłe, 25-28 x 8-11 µm, o proporcji L:D 2.5-3, ze stożkowato zwężającą się częścią szczytową; ich powierzchnia delikatnie szorstka . . . . . *N. tetranychi*, str. 143

10*. Kapilikonidia krótsze niż 24 µm, o proprocji L:D 2-2.2, gładkie; zarodniki przetrwalnikowe 14-25 x 14-22 µm . . . . *N. floridana*, str. 142

Rodzaj *Strongwellsa*

Klucz do gatunków

1. Konidia pierwotne wąsko jajowate o liniach bocznych w obrysie wyraźnie zbieżnych ku nasadzie, 25-33 x 12-19 µm, o proporcji L:D rzadko osiągającej 2; w imagines *Anthomyiidae* . *S. castrans*, str. 144

1*. Konidia pierwotne wąsko elipsoidalne lub cylindryczne o zaokrą — glonych końcach, o bokach niemal równowąskich lub nieco zgrubiałe w części przynasadowej, 30-40 x 12-17 µm, o proporcji L:D ca 2.4; w muchówce *Fannia cunicularis* (*Muscidae*) . . . . . *S. magna*, str. 145

Rodzaj *Massospora*

Ze względu na brak danych o występowaniu gatunków z tego rodzaju w Europie charakterystyk morfologicznych i kluczy do oznaczania nie włączono do niniejszego opracowania. Spis gatunków, ich gospodarzy i miejsca zbioru podano w anglojęzycznej części tekstu (str. 145) na podstawie prac S o p e r a (1974, 1981).

Rodzaj *Zoophthora*

Klucz do podrodzajów

1. Pseudocystydy wyraźnie dwu- lub kilkakrotnie grubsze od trzonków konidialnych, zwykle długie i często na końcach zgrubiałe, guzkowate lub z 1-2 krótkimi wyrostkami; konidia wtórne, oprócz zwykłych (podobnych do pierwotnych) często także małe okrągło-gruszkowate lub z gwiaździstymi wyrostkami (tetraradiate); ryzoidy monohyfalne bez szczytowych przylg; głównie w mokrych, nadwodnych środowiskach . . . . . Z. subg. *Erynia*, str. 149

1*. Pseudocystydy nie grubsze lub nieznacznie grubsze od trzonków konidialnych, często słabo wyróżniające się; konidia wtórne podobne do pierwotnych lub kapilispory; ryzoidy pojedyncze lub wiązkowate, zakończone tarczowatymi przylgami lub grupami nieco posplatanych odgałęzień 2

2. Kapilispory i wiązkowate ryzoidy (pseudoryzomorfy) występują; konidia pierwotne cylindryczne lub elipsoidalne o papillach nieznacznie węższych od średnicy zarodników . . . . . Z. subg. *Zoophthora*, str. 201

2*. Kapilispor i wiązkowatych ryzoidów brak; konidia pierwotne zwykle gruszkowate lub krótko maczugowate, rzadko wydłużone, zbliżone do elipsoidalnych 3

3. Ryzoidy monohyfalne, tasiemkowate, o grubości trzonków konidialnych lub niewiele grubsze, zakończone tarczowatymi przylgami o zatokowatych brzegach lub z siateczkowatymi splotami nieregularnych odgałęzień w miejscach styku z podłożem (u *Z. delphacis* ryzoidów brak) . . . . . Z. subg. *Neopandora*, str. 171

3*. Ryzoidy nie grubsze od trzonków konidialnych lub powietrznych strzępek wegetatywnych, bez wyróżnialnych przylg lub najwyżej z kilkoma luźnymi krótkimi odgałęzieniami na końcu, niekiedy ryzoidy tworzą luźny splot nie mający charakteru zwartej pseudoryzomorfy . . . . . Z. subg. *Furia*, str. 160

Podrodzaj Erynia

1. Konidia pierwotne zwężające się ku szczytowi i często ostre na końcach 2
1*. Konidia pierwotne o szeroko zaokrąglonych szczytach 3

2. Konidia pierwotne 25-80 x 12-14 µm z dość szeroką nasadą, nieco poszerzone wyżej, po czym zwężające się równomiernie stożkowato ku ostremu lub nieco przytępionemu szczytowi; na imagines *Chironomidae* i *Culicidae* . . . . . *Z. conica*, str. 154
2*. Konidia pierwotne 30-45 x 7-9 µm, najgrubsze w połowie długości po czym gwałtownie zwężające się w wyciągniętą, raczej cienką część dystalną; na drobnych muchówkach w wilgotnych środowiskach nadwodnych . . . . . *Z. gracilis*, str. 156

3. Konidia pierwotne o silnie poszerzonej części dystalnej, gruszkowate lub maczugowate, z około 10 µm długą, stożkowatą papillą o nieco tępym szczycie; na larwach, poczwarkach i imagines ochotkowatych (*Chironomidae*) i komarów (*Culicidae*), zwykle pływających na powierzchni wody . . . . . *Z. aquatica*, str. 152
3*. Konidia pierwotne jajowate, wąsko maczugowate lub obło-wrzecionowate, często wygięte, z krótkimi papillami w zarysie łukowatymi lub trójkątnymi 4

4. Konidia pierwotne zwykle jajowate, proste, promienistosymetryczne, rzadko z papillą nieco odgiętą od podłużnej osi zarodnika 5
4*. Konidia pierwotne zwykle wygięte, bilateralnie symetryczne 9

5. Konidia pierwotne odwrotnie stożkowate lub wąsko jajowate, z bardzo wąskimi papillami, nie szerszymi niż 1/3 maksymalnej grubości zarodnika 6
5*. Konidia pierwotne kulistawo-jajowate, maczugowate lub obło-wrzecionowate 7

6. Konidia pierwotne 18-25 x 11-15 µm; patogen drobnych muchówek długoczułkowych (*Nematocera*) . . . . . *Z. montana*, str. 156
6*. Konidia pierwotne 12.5-20 x 7-13.5 µm; patogen mszyc . . . . . *Z. erinacea*, str. 155

7. Konidia pierwotne od owalnych do nieco butelkokształtnych, 14-16 x 6-8 µm, z krótkim, szyjkowatym przewężeniem przy nasadzie, zamkniętym prawie poziomo ściętą papillą; zygospory elipsoidalne, 40-46 x 23-32 µm; na muchówkach (*Anthomyiidae*) . . . . . *Z. delpiniana*, str. 155

7*. Konidia pierwotne z wyraźnie uwypuklonymi papillami; zygospory, jeśli występują, kuliste 8

8. Konidia pierwotne 22-28 x 12-14 µm, regularnie jajowate, z papillami o zarysie łukowatym o szerokości równej połowie grubości zarodnika; zygospory około 31 µm średnicy; na imagines muchówek w wilgotnych miejscach . . . . . *Z. ovispora*, str. 151

8*. Konidia pierwotne od jajowatych do maczugowatych, 16-42 x 10-19 µm, najczęściej ca 33-16 µm, rzadko nieco wygięte przy nasadzie; papilla 5-7 µm szerokie; na dorosłych okazach *Nemouridae (Plecoptera)* . . . . . *Z. plecopteri*, str. 157

9. Konidia pierwotne o zróżnicowanych kształtach, szeroko gruszkowate około 15 x 11 µm oraz maczugowate, często wygięte, 18-30 x 7-9 µm; na małych muchówkach w mokrych środowiskach . *Z. variabilis*, str. 159

9*. Konidia pierwotne o gruszkowatym kształcie nie występują; wydłużone konidia o niezbyt regularnym kształcie, często wygięte, większe i grubsze 10

10. Konidia pierwotne obło-wrzecionowate, 35-48 (-55) x 10-15 µm, przeważnie proste lub tylko z odgiętą od osi ponadpapillarną szyjką; pseudocystydy nawet do 70-90 µm grubości, często z odgałęzieniami na szczytach; na imagines *Tipulidae* i innych muchówek . . . . . *Z. sepulchralis*, str. 158

10*. Konidia pierwotne przeważnie maczugowate lub rogalikowate, zwykle wygięte 11

11. Konidia pierwotne wąsko rogalikowate, maczugowate lub niekiedy obło-wrzecionowate, 30-35 x 8-10 µm, zwykle najgrubsze w części centralnej; zygospory o średnicy 40-60 µm, tworzone na powierzchni ciała gospodarza, o brunatnym episporium z przylegającym i do niego strzępkami; na *Trichoptera* . . . . . *Z. rhizospora*, str. 158

11*. Konidia pierwotne wygięte, o obu końcach tępych, 25-40 x 10-15 µm, najgrubsze w części szczytowej; zygospory bezbarwne, tworzone wewnątrz gospodarza; na muchówkach . . . . . *Z. curvispora*, str. 154

Podrodzaj Furia

Klucz do gatunków

1. Konidia pierwotne cylindryczne, wąsko-maczugowate lub obło-wrzecionowate, o proporcjach L:D 2.2-3.2 2
1*. Konidia pierwotne jajowate do gruszkowatych, o proporcjach L:D około 2 lub mniej; papille równe najwyżej połowie grubości zarodników . 4
2. Konidia pierwotne wąsko-owoidalne lub maczugowate, w większości 19-21 x 7.5-10.5 µm; przetrwalniki szorstkie, czarne, o średnicy 40-58 µm, nieco spłaszczone; na gąsienicach rolnic (*Lepidoptera: Noctuidae, Agrotinae*) . . . . . *Z. gammae*, str. 167
2*. Konidia pierwotne niemal cylindyczne, obło-wrzecionowate lub maczugowate, średnio 30 µm długie 3
3. Konidia pierwotne równowąskie lub tępo wrzecionowate (24-) 28- 30 (-32) x (9-) 10-11 (-12) µm; papille wyraźnie szersze niż połowa grubości zarodników; na gąsienicach sówkowatych (*Noctuidae*), głównie rolnic . . . . . *Z. virescens*, str. 169
3*. Konidia pierwotne wąsko-maczugowate, 27-33 x 8.5-10 µm, z niemal cylindryczną częścią szczytową równą około 2/3 długości zarodnika, natomiast w nasadowej 1/3 słabo zbieżne ku papilli ca 4.5 µm szerokiej; na imago muchówki krótkoczułkowej (*Diptera: Brachycera*) . . . . . *Z. fumimontana*, str. 166
4. Zarodniki przetrwalnikowe ciemnobrunatne, gładkie lub brodawkowate; patogen larw chrząszcza *Zabrus tenebrioides* (*Carabidae*) . . . . . *Z. zabri*, str. 170
4*. Zarodniki przetrwalnikowe bezbarwne lub najwyżej kremowe albo żółtawe w masie; patogeny innych owadów 5
5. Patogeny motyli (*Lepidoptera*) 6
5*. Patogeny innych owadów 9
6. Na imagines omacnicowatych (*Pyralidae*) i innych motyli; konidia pierwotne gruszkowate do jajowatych, 16-28 x 12-17 µm, z szerokimi, tępymi lub wąsko-stożkowatymi papillami . . *Z. neopyralidarum*, str. 168
6*. Na gąsienicach 7
7. Konidia pierwotne gruszkowate, stosunkowo duże, średnio 32 x 25 µm; zarodniki przetrwalnikowe kuliste, małe, 10-28 µm; na *Creatonotus gangis* (*Arctiidae*) . . . . . *Z. creatonoti*, str. 164
7*. Konidia pierwotne zwykle jajowate, 20-27 x 9.5-16 µm; pojedyncze wyjątkowo przekraczają 30 µm długości 8

8. Konidia pierwotne wąsko-jajowate, 16.5-25.5 x 6.5-12 µm; zygospory o średnicy 21-42 µm; na *Malacosoma* spp. (*Lasiocampidae*) . . . . . *Z. gastropachae*, str. 164

8*. Konidia pierwotne większe. 21-32.5 x 11.5-23.7 µm, o szeroko zaokrąglonej części szczytowej; na *Pieris rapae* (*Pieridae*) . *Z. pieris*, str. 171

9. Patogeny muchówek (*Diptera*) 10

9*. Patogeny innych owadów 11

10. Konidia pierwotne elipsoidalne lub wąsko-jajowate, 28-30 x 14 µm — pojedyncze mogą być większe — ku dołowi zwężające się w ponadpapilarną szyjkę; na dużych muchówkach z grupy *Calyptrata* (*Musca, Lucilla, Calliphora*) . . . . . *Z. americana*, str. 162

10*. Konidia pierwotne jajowate do odwrotnie stożkowatych, 18-25 x 12-16 µm, zwężające się prostolinijnie, niemal stożkowato, ku małym papillom; na muchówkach z rodziny *Sciaridae* . . . . . *Z. sciarae*, str. 169

11. Konidia pierwotne małe, (12-) 14-15 (-17) x (7-) 8-9 (-10) µm, krótko jajowate do gruszkowatych; na *Lygus* sp. (*Heteroptera*: *Miridae*) . . . . *Z. minutospora*, str. 168

11*. Konidia pierwotne znacznie większe, 22-28 x 13-16.5 µm; na *Forficula auricularia* (*Dermaptera: Forficulidae*) . . . . . *Z. ellisiana*, str. 165

Podrodzaj Neopandora

1. Patogeny pajęczaków: kosarzy (*Opiliones*) i roztoczy (*Acarina*) . . . . *Z. phalangicida*, str. 196

1*. Patogeny owadów (*Insecta*) 2

2. Patogeny dorosłych muchówek (*Diptera*) 3

2*. Patogeny innych owadów 10

3. Przetrwalniki grubokolczaste lub brodawkowate, powszechnie wytwarzane na gospodarzach 4

3*. Przetrwalniki — jeśli występują — gładkie, delikatnie szorstkie, względnie płytko urzeźbione 5

4. Konidia pierwotne elipsoidalne, 21-27 x 9-12 (-14) µm; konidia wtórne nie podobne do pierwotnych, głównie krótko jajowate z prawie równo ściętą papillą i często ze słabo zaznaczonym apikalnym punktem, z dużą, okrągłą wakuolą w środku, poniżej dyskowato spłaszczonego jądra; zarodniki przetrwalnikowe grubo szorstko kolczaste, żółte do gliniastych w masie, czasem z pomarańczowym odcieniem; na muchach z rodziny *Lauxaniidae* i pokrewnych . . . . . *Z. echinospora*, str. 185

4*. Konidia pierwotne 23-37.5 x 12-16 µm; konidia wtórne podobne do pierwotnych; zarodniki przetrwalnikowe z gęstą, grubą, tępo granulkowatą szorstkością na powierzchni; na muchówkach . . . *Z. bullata*, str. 179

5. Konidia pierwotne wąsko-jajowate, elipsoidalne lub tępo-wrzecionowate; zarodniki przetrwalnikowe kuliste, gładkie, bezbarwne; na muchówkach, głównie małych *Nematocera* . . . . . *Z. dipterigena*, str. 185
5*. Konidia pierwotne o kształcie owoidalnym 6

6. Konidia pierwotne 20-24 x 11-13 µm, z wypukłością papillarną łagodnie przechodzącą w kontur zarodnika; zarodniki przetrwalnikowe kuliste, gładkie, orzechowo-brunatne, ca 30 µm; na muchówkach krótkoczułkowych (*Brachycera*) . . . . . *Z. muscivora*, str. 194
6*. Wypukłość papillarna konidiów pierwotnych wyraźnie uwydatniająca się na zarysie zarodników 7

7. Konidia pierwotne stosunkowo duże, 28-44 x 12-19 µm; przetrwalniki bezbarwne, gładkie o średnicy 25-52 µm 8
7*. Konidia pierwotne mniejsze, 14-25 x 8-14 µm; przetrwalniki gładkie lub płytko nieregularnie bruzdkowane, o falistym konturze 9

8. Konidia pierwotne 28-44 x 12-19 µm; ryzoidy pojedyncze z tarczowatymi przylgami, nie tworzące zwartego splotu strzępek wokół ciała gospodarza; na muchówkach z rodziny *Calliphoridae* . . . . . *Z. vomitoriae*, str. 201
8*. Konidia pierwotne 28-30 (-35) x 14-15 µm; przetrwalniki o średnicy 35-48 (-50) µm; rizoidy bez tarczowatych przylg, skupione w ciągły splot grzybniowy wokół ciała gospodarza; na dużych muchówkach z grupy *Calyptrata* . . . . . *Z. americana*, str. 162
podrodz. *Furia*

9. Konidia pierwotne z silnie oddzieloną zewnątrzną ścianą, jajowate ca 18 x 12 µm; przetrwalniki kuliste, gładkie; na małych muchówkach długoczułkowych (*Nematocera*) . . . . . *Z. gloeospora*, str. 191
9*. Konidia pierwotne o normalnym rozwarstwieniu ściany, 14-24 x 8.5-12 µm; przetrwalniki o średnicy 26-41 µm, w masie rdzawobrunatne, z nieregularnie bruzdkowanym episporium, o grubo szorstkim lub falistym konturze; na muchówkach z rodzin *Rhagionidae* i *Empididae* . . . . . *Z. ithacensis*, str. 191

10. Patogeny chrząszczy (*Coleoptera*) 11
10*. Patogeny innych owadów 14

11. Na larwach *Zabrus tenebrioides* (*Carabidae*); konidia pierwotne ca 25 x

14 µm (max. 29 x 18 µm); przetrwalniki czarnobrunatne, o średnicy 33-40 µm, z gładkim lub brodaweczkowanym episporium *Z. zabri*, str. 170
podrodz. *Furia*

11*. Na dorosłych chrząszczach; wymiary konidiów pierwotnych 19-30 x 9-15 µm 12

12. Konidia pierwotne podłużnie jajowate lub elipsoidalne, zwykle gwałtownie zwężone przy nasadzie w krótką szyjkę, z której uwypukla się papilla 3-4 (-4.5) µm szeroka; pseudocystydy wzraźne i liczne 300-400 µm długości 13
12*. Konidia pierwotne raczej szeroko jajowate; papille 6-7 µm szerokości, uwypuklające się bezpośrednio na zarysie konidiów, bez szyjkowatego przewężenia; pseudocystydy nieliczne, 70-150 µm długości 14

13. Na niektórych omomiłkowatych (*Cantharidae*); konidia pierwotne (17-) 18.5-23 (-26) x (9-) 9.5-12 (-13) µm, zwykle gwałtownie przewężone przy nasadzie w krótką ponadpapillarną szyjkę . . . . *Z. lipai*, str. 192
13*. Na *Phyllobius sp.* (*Curculionidae*); konidia pierwotne wąsko-jajowate, 20-23 x 10-11,5 µm lub podłużnie-elipsoidalne, 23-31 x 11.5-14.5 µm, w obu przypadkach stożkowato zwężające się ku papilli . . . . . *Z. phyllobii*, str. 199

14. Konidia pierwotne (19-) 21-26 x 11-13 (-14,5) µm, o papillach zaznaczających się w konturze zarodników jako niemal półkuliste uwypuklenia; przetrwalniki nieznane na chrząszczach *Philonthus* spp. (*Staphylinidae*) . . . . . *Z. philonthi*, str. 197
14*. Konidia pierwotne 18-22 (-24,5) x 10-14 (-16) µm, z papillami słabo i łagodnie uwypuklonymi z obrysu zarodników, często niemal prostolinijnymi; przetrwalniki nieznane; na chrząszczach z plemienia *Galerucini* (*Chrysomelidae*) . . . . . *Z. suturalis*, str. 200
14**. Konidia pierwotne 18-22 x 11-15 µm; zygospory bezbarwne, kolczaste o średnicy 22-39 µm (śr. 29 mm); na chrząszczach *Anomala rufiventris* i *Brahmina* sp. (*Scarabaeidae*) . . . . . *Z. brahminae*, str. 178

15. Patogeny pluskwiaków (*Rhynchota*) 16
15*. Patogeny innych owadów 22

16. Typowe patogeny mszyc; inne owady mogą ulegać infekcji w eksperymentach laboratoryjnych 17
16*. Typowe patogeny skoczków (*Auchenorrhyncha*), mączlikowatych (*Aleurodidae*) lub pluskwiaków różnoskrzydłych (*Heteroptera*) . . . 19

17. Konidia pierwotne jajowate lub elipsoidalne, (15-) 21-32 (-40) x (9-) 11-

14 (-16) µm, o papillach zawsze wyraźnie węższych niż połowa grubości zarodnika; na różnych mszycach . . . . . *Z. neoaphidis*, str. 175

17*. Konidia pierwotne jajowate, zwykle mniejsze, tylko pojedyncze przekraczają 25 µm długości 18

18. Konidia pierwotne krótko jajowate, (12-) 15-16.5 (-20) x (7-) 8-10.5 (-12) µm, bez ponadpapillarnego zwężenia, o raczej szerokich papillach; na mszycach *Pemhigus bursarius, Aphis umbrella* i pokrewnych . . . . . *Z. nouryi*, str. 195

18*. Konidia pierwotne (14-) 16-24 (-27) x (7-) 10-12 (-15) µm, jajowate lub krótko elipsoidalne, z silnie uwypuklonymi, półkulistymi papillami; na mszycach *Acyrtosiphon kondoi*, eksperymentalnie także na pokrewnych . . . . . *Z. kondoiensis*, str. 195

19. Patogeny skoczków (*Auchenorrhyncha*) 20

19*. Patogeny innych pluskwiaków 21

20. Konidia pierwotne 29-35.5 x 13-17.5 µm; ryzoidów brak; na *Delphacidae*, eksperymentalnie także na mszycach . . . . *Z. delphacis*, str. 183

20*. Konidia pierwotne zawsze krótsze, jajowate, 17.5-22.5 x 9.5-11 µm, w 1/3 części nasadowej stopniowo zwężające się ku papillom 5-6 µm szerokim; na *Jassidae* . . . . . *Z. poloniaemajoris*, str. 180

21. Konidia pierwotne do 20 µm długości, gruszkowate, w nasadowej połowie zwężające ku 3-3.5 µm szerokiej papilli; na mączlikowatych (*Aleurodidae*) . . . . . *Z. aleurodis*, str. 176

21*. Konidia pierwotne elipsoidalne, o części nasadowej silnie zwężonej, zamkniętej papillą 3-4 µm szeroką; na pluskwiakach różnoskrzydłych (*Heteroptera*) . . . . . *Z. heteropteris*, str. 188

22. Patogeny błonkoskrzydłych (*Hymenoptera*) 23

22*. Patogeny innych owadów 24

23. Konidia pierwotne wąsko elipsoidalne lub tępo wrzecionowate, rzadko wąsko jajowate; na larwach *Athalia rosae* (*Tenthredinidae*) . . . . . *Z. athaliae*, str. 177

23*. Konidia pierwotne krótko jajowate do nieco gruszkowatych, o raczej krótkiej, szerokiej papilli; na imagines *Hymenoptera* 24

24. Patogeny robotnic mrówek; ryzoidy nieliczne, wyrastające tylko z tułowia; na *Formica* spp. . . . . *Z. myrmecophaga*, str. 188

24*. Patogen męczelkowatych (*Braconidae*); ryzoidy liczne wyrastające z brzusznej strony tułowia i odwłoka; na *Dacnusa* sp. . . . . *Z. dacnusae*, str. 183

25. Na gąsienicach motyli (*Lepidoptera*); konidia pierwotne (13-) 15-18

(-20) x (7-) 15-18 (-20) x 7-9 (-11) µm, jajowate i gruszkowate, w nasadowej połowie zwężające się ku półkulistej papilli, ca 4 µm szerokości . . . . . *Z. blunckii*, str. 178

25*. Na skorkach *Forticula auricularia*; konidia pierwotne (20-) 22.5-25.5 (-28.5) x 13-16 µm, elipsoidalne lub szeroko jajowate, słabo zwężone przy nasadzie w bardzo krótką ponadpapillarną szyjkę; papilla ca 7 µm szerokości . . . . . *Z. ellisiana*, str. 165

podrodz. *Furia*

Podrodzaj Zoophthora

Klucz do gatunków

1. Konidia pierwotne krótko elipsoidalne o proporcji L:D poniżej 2 lub dwa rodzaje konidiów: cylindryczne o proporcji L:D około 3 oraz owoidalne lub krótko elipsoidalne wyraźnie grubsze 2

1*. Konidia pierwotne jednego typu, wysmukło elipsoidalne lub cylindryczne, o proporcjach L:D zawsze przekraczających 2 3

2. Konidia pierwotne jednego typu — krótko elipsoidalne, 15-22 x 10-12 µm; na imagines miernikowców (*Lepidoptera: Geometridae*) . . . . . *Z. geometralis*, str. 229

2*. Konidia pierwotne 2 typów: jajowate lub krótko elipsoidalne, 12.5-31 x 8-16.5 µm, oraz wąsko elipsoidalne 17-33 x 6-13 µm; na mszycach *Myzus persicae* (*Aphidae*) . . . . . *Z. anhuiensis*, str. 211

3. Średnia długość konidiów pierwotnych nie przekracza 20 µm, tylko pojedyncze mogą wyjątkowo osiągać 25 µm długości 4

3*. Średnia długość konidiów pierwotnych 20 µm lub więcej; przynajmniej znaczna ich część przekracza 25 µm długości 14

4. Centralna i prawie cylindryczna część kapilispor stosunkowo długa, osiągająca około połowy całkowitej długości kapilispory, a nasadowe i końcowe części są stożkowate; proporcje L:D konidiów pierwotnych 2.7-2.8 µm, kapilispor 3.9-4.5 µm; kolonie na pożywkach z żółtkiem filcowate o barwie grzybni winno-purpurowej; na dorosłych muchówkach z rodziny *Dryomyzidae*, w jesieni . . . . . *Z. autumnalis*, str. 218

4*. Kapilikonidia o wygiętych na zarysie lub zbieżnych liniach bocznych, bez wyraźnej wydłużonej centralnej części cylindrycznej; kolonie w kulturach białe, kremowe lub z wiekiem słabo brunatniejące 5

5. Kapilikonidia wysmukłe, zwykle 20-30 µm długości, o proporcji L:D około 4-6, równomiernie zwężające się ku szczytowi 6
5*. Kapilikonidia około 15-20 µm długości, o proporcji L:D zwykle nie przekraczającej 3 lub zbliżonej do tej wartości 9

6. Kapilikonidia, zwłaszcza pierwszych serii, wyraźnie hiperbolicznie wygięte mniej więcej w połowie swej długości; na mrówce *Myrmina laevinodis* (*Myrmicidae*) . . . . . *Z. falcata*, str. 225
6*. Kapilikonidia słabo wygięte lub tylko bilateralnie asymetryczne, z linią brzuszną prawie prostą lub niewyraźnie wklęsłą 7

7. Na chrząszczach *Tachyporus* sp. (*Coleoptera: Staphylinidae*); linia brzuszna kapilispor niemal prosta lub tylko zaledwie dostrzegalnie wklęsła w górnej części . . . . . *Z. tachypori*, str. 248
7*. Na imagines *Diptera*; wentralna linia kapilispor prosta lub słabo wygięta, w części dolnej nieco wypukła, w części górnej wklęsła 8

8. Kapilikonidia lancetowate, najgrubsze w przynasadowej połowie; konidia pierwotne 15-24 x 6-9 µm; przetrwalniki bezbarwne; na drobnych muchówkach . . . . . *Z. lanceolata*, str. 235
8*. Kapilikonidia wrzecionowate, najgrubsze w połowie ich długości, z profilu o zarysie łukowatym, niemal bipolarnie symetryczne; konidia pierwotne 17-22 x 5,5-6,2 µm; przetrwalniki przydymione, o czarniawobrunatnym episporium; na *Opomyzidae* i pokrewnych *Z. opomyzae*, str. 237

9. Kapilikonidia — zwłaszcza na PDA — o tępych końcach lub ich linie boczne tworzą stożkowaty, przytępiony szczyt, nie wydłużony w dziobek lecz czasem z terminalną, nieregularną przylgą (haptor) 10
9*. Wygięcia linii grzbietowej i brzusznej na profilu kapilispor tworzą ostre lub nieco przytępione, krótkie, dziobkowate wydłużenie szczytu wygięte ku brzusznej stronie 12

10. Konidia pierwotne krótkie, — 15.5-16.5 x 5.5-6.2 µm, wyjątkowo dłuższe; kapilikonidia bardzo rzadkie; wzrost na pożywkach bardzo słaby, bez typowego zarodnikowania; na gąsienicach liściożernych miernikowców (*Geometridae*), wczesną wiosną . . . . . *Z. brevispora*, str. 221
10*. Konidia pierwotne najczęściej 17-19.5 µm długości; wzrost i sporulacja na pożywkach z żółtkiem normalne 11

11. Kapilikonidia z owadów wrzecionowate, po stronie brzusznej słabiej wypukłe, zakończone stożkowato, u kapilispor uzyskanych na pożywce PDA szczyt zaokrąglony; na larwach *Arge berberidis* (*Hymenoptera: Argidae*) . . . . . *Z. arginis*, str. 217
11*. Kapilikonidia z profilu wyraźnie asymetryczne, o linii brzusznej podwójnie wygiętej — słabo wypukłej w części dolnej oraz wklęsłej pod szczy-

tem, czasem ze szczątkową nieregularną przylgą (haptor); na drobnych muchówkach długoczułkowych (*Diptera: Nematocera*) . . . . . *Z. nematoceris*, str. 240

12. Patogen koliszek (miodówek) (*Psyllodea*); kapilikonidia w większości migdałowate z dziobkowatym wydłużeniem szczytu dość grubym i zaznaczającym się dzięki płytkiemu wklęśnięciu podszczytowego odcinka linii brzusznej; na *Trioza urticae* . . . . . *Z. psyllae*, str. 247

12*. Patogeny innych owadów; dziobkowate wydłużenie kapilispor mniej wyraźne i grubsze, zaznaczone głównie przez niejednakowe wygięcie centralnej i szczytowej części linii grzbietowej. 13

13. Patogeny pluskwiaków z rodziny *Miridae*, okazyjnie spotykane również na skoczkach (*Auchenorrhyncha*); dziobkowate wydłużenie kapilispor uzyskanych na pożywce PDA wyraźne, stożkowate lub przytępione . . . . . *Z. miridis*, str. 238

13*. Na imagines gąsieniczników (*Hymenoptera; Inchneumonidae*); kapilikonidia na PDA z raczej ostrym lecz słabo wydłużonym szczytem . . . . . *Z. ichneumonis*, str. 231

14. Średnia długość konidiów pierwotnych wynosi ca 20 µm lecz dość liczne są krótsze lub przekraczajce 25 µm długości 15

14*. Konidia pierwotne wyraźnie dłuższe, ca 25-40 µm 17

15. Centralne, niemal cylindryczne odcinki kapilikonidiów stosunkowo długie, obydwa ich końce krótko stożkowate i na szczytach tępe; na pasikonikowatych *Meconema thalassinum i Leptophyes punctatissima (Orthoptera: Tettigoniidae)* . . . . . *Z. giardii*, str. 230

15*. Kapilikonidia w zarysie z łukowatymi lub falistymi liniami grzbietową i brzuszną, bez wyraźnej, długiej, centralnej części cylindrycznej . . . 16

16. Wymiary konidiów pierwotnych raczej stałe, 20-20.5 µm; pojedyncze są krótsze od 20 µm lub dłuższe od 25 µm, proporcja L:D około 3.4; kapilikonidia wydłużone, wygięte, bardzo słabo zwężające się ku szeroko zaokrąglonemu szczytowi; na muchówkach krótkoczułkowych (*Diptera: Brachycera*). . . . . *Z. obtusa*, str. 241

16*. Długość konidiów pierwotnych u poszczególnych szczepów wynosi 19-25 µm, lecz absolutny zakres zmienności kształtuje się w szerszych granicach (róznice wynoszą 5-10 µm), proporcje L:D od 3.6-4.5; kapilikonidia o linii grzbietowej silnie, a brzusznej słabo wypukłej, obydwie linie często w górnej części łagodnie płytko wklęsłe dzięki czemu uwydatnia się krótki dziobek, w kulturach na PDA zaostrzony; na gąsienicach bielinków *Pieris brassicae* i *P. rapae*, a zarodniki przetrwalnikowe także w poczwarkach . . . . . *Z. radicans*, str. 207

17. Długość konidiów pierwotnych rzadko przekracza 30 µm, u poszczególnych szczepów mierzą one 21-30 x 6.5-10 µm, o proporcji L:D 2.8-3.5 18
17*. Konidia pierwotne zwykle ponad 30 µm długości, mierzą najczęściej 27-40 x 2.8-3.5 µm; proporcje L:D 2.5-4.5 dla poszczególnych szczepów 27

18. Kapilikonidia wrzecionowate o ostrych lub przytępionych szczytach 19
18*. Końce kapilispor zaokrąglone lub krótko dziobkowate o tępych szczytach 20

19. Konidia pierwotne 21-25 x 6.6-7.3 µm o proporcji L:D 3.3-3.5; na skorkach (*Dermaptera*) . . . . . *Z. forficulae*, str. 226
19*. Konidia pierwotne średnio 25 x 10 µm o proporcji L:D około 2.5; na mszycach *Schizolachnus pini-radiatae* . . . . . *Z. canadensis*, str. 222

20. Proporcja L:D kapilispor około 2; ich jajowata część nasadowa zwęża się ku górze w asymetryczny, krótki dziobek odchylony w kierunku strony brzusznej dzięki dość głębokiemu zaklęśnięciu linii brzusznej w części przyszczytowej; konidia pierwotne 22.5-25.5 x 7.5 µm; na skoczkach (*Auchenorrhyncha*) . . . . . *Z. petchii*, str. 243
20*. Proporcja L:D kapilispor 3-4 lub więcej, ich szczyty równomiernie zaokrąglone, bez terminalnych dziobków 21

21. Patogen mszyc; kapilikonidia migdałowate, 24.5-29.5 x 5,5-10.3 µm; konidia pierwotne 23.7-31.6 x 6.3-10.3 µm . . . . . *Z. orientalis*, str. 243
21*. Na innych owadach 22

22. Na imagines *Tipulidae (Diptera)*; kapilikonidia wąsko wrzecionowate o proporcji L:D ca 6.5 . . . . . *Z. humberi*, str. 231
22*. Na innych owadach 23

23. Grzybnia lub powierzchnia kolonii w kulturach pożywkowych zielona z obfitym zarodnikowaniem konidialnym; kapilifory 60-110 µm długie, 3-5-krotnie dłuższe od kapilispor, które są wysmukłe, wąsko wrzecionowate lub o kształcie banana 24
23*. Grzybnia na pożywkach biała do kremowej lub brudnożółtej, słabo rozwijająca się, skąpo zarodnikująca lub nie wytwarzająca konidiów; kapilifory stosunkowo grube, najwyżej 2-2.5 razy dłuższe od kapilispor . 25

24. Konidia pierwotne 25-35 x 7-10 µm, cylindryczne, o szeroko zaokrąglonych końcach; na imagines sprężykowatych z rodzaju *Agriotes (Coleoptera: Elateridae)* . . . . . *Z. anglica*, str. 209

24*. Konidia pierwotne zazwyczaj 21-26 x 8-9 µm, wąsko wrzecionowate o zaokrąglonych końcach; na *Notostira elongata* (*Heteroptera: Miridae*) . . . . . *Z. viridis*, str. 249

25. Na larwach i poczwarkach *Phytonomus* spp. (*Coleoptera: Curculionidae*); konidia pierwotne przeważnie 23-26 x 7 µm, o proporcji L:D ca 3.2-3.6 . . . . . *Z. phytonomi*, str. 245
25*. Na gąsienicach lub dorosłych motylach (*Lepidoptera*) 26

26. Na gąsienicach liściożernych miernikowców (*Geometridae*) wczesną wiosną; konidia pierwotne 23-30 x 6.5-8.5 µm, o proporcjach L:D 3.4-3.9; brzuszna linia kapilikonidiów wypukła, czasem ze słabo zaznaczonym podszczytowym wklęśnięciem, lecz nigdy rogalikowate; kapilifory stosunkowo grube, zwykle tylko nieznacznie dłuższe od kapilispor . . . . . *Z. bialoviezensis*, str. 219
26*. Na imagines *Celypha flavipalpana* (*Torticidae*) w pełni lata; konidia pierwotne 25-31 x 8.5-9.5 um, o proporcji L:D 2.7-3.5; brzuszna linia rogalikowatych kapilispor słabo wklęśnięta na całej długości lub prawie prosta; kapilifory cienkie, zwykle nieco ponad dwukrotnie dłuższe od kapilispor . . . . . *Z. crassispora*, str. 223

27. Patogeny mszyc 28
27*. Patogeny chrząszczy 30

28. Konidia pierwotne cylindryczne, niekiedy zgięte, z obu końcami zaokrąglonymi, 26-34 x 7-8 µm; przetrwalniki nieznane . . . . . *Z. phalloides*, str. 244
28*. Konidia pierwotne 28-35 µm, długości ze stożkowato zwężającą się częścią szczytową; przetrwalniki kuliste, zwykle wytwarzane 29

29. Konidia pierwotne 7.5-9.5 µm grubości, o proporcji L:D 3-4.5; kapilikonidia z linią brzuszną płytko wygiętą w kształcie litery s, w części górnej silniej wklęśniętą, wydłużone w zaznaczający się krótki, tępy dziobek; przetrwalniki bezbarwne o średnicy 27-29 µm . . . . . *Z. occidentalis*, str. 242
29*. Konidia pierwotne 9-12 µm grube, o proporcji L:D 2.5-3.3; wklęśnięcie brzusznej linii kapilikonidiów w górnej części bardzo słabo zaznaczone, szczyt tępy; przetrwalniki czarnobrunatne, o średnicy 36-41 µm . . . . . *Z. aphidis*, str. 211

30. Konidia pierwotne wysmukłe, 40-41 (-46) x 7.5-9 µm, o proporcji L:D około 4.5; kapilikonidia i przetrwalniki nieznane; na larwie *Cantharidae* . . . . . *Z. larvivora*, str. 235

30*. Konidia pierwotne 25-35 x 8.5-12 µm, o proporcji L:D około 3; kapiliko-

nidia wydłużone, słabo sierpowato wygięte, 33-39 x 8-9 µm; przetrwalniki kuliste, 35-56 µm, brunatne; na imagines *Cantharidae* . . . . . *Z. crassitunicata*, str. 224

Forma-rodzaj *Tarichium*

1. Przetrwalniki występujące w owadach 2
1*. Przetrwalniki występujące w roztoczach 23

2. Episporium gładkie 3
2*. Episporium ornamentowane 8

3. Przetrwalniki bezbarwne lub jasno- albo złocistożółte 4
3*. Przetrwalniki ciemnozabarwione, w masie brunatne lub orzechowe . 5

4. Przetrwalniki o średnicy 20-30 µm z episporium 3-4 µm grubości; często występują wiązkowate ryzoidy; w różnych gatunkach owadów . . . . . *T. sphaerospermum-complex*, str. 266
4*. Przetrwalniki o średnicy 35-45 µm z episporium 2-2.5 µm grubości; w skoczku *Euacanthus interruptus (Cicadellidae)* *T. jaapianum*, str. 261

5. Przetrwalniki kuliste, rzadko jajowate, do 30 µm, lub największe do 50 µm średnicy; wiązkowate ryzoidy zwykle występują 6
5*. Przetrwalniki kuliste, 14-35 µm; ryzoidy, jeśli występują to pojedyncze, nie połączone w wiązki; na muchówkach 7

6. Przetrwalniki orzechowo-brązowe lub brunatne o średnicy 43-55 (-62) µm lub owalne 61-68 x 56 µm; w chrząszczach *Rhagonycha lignosa* i *R. fulva (Cantharidae)* . . . . . *T. rhagonycharum*, str. 265
6*. Przetrwalniki kuliste, 30-53 µm, zwykle 37-41 µm, czarnobrunatne; na mszycach *Anoecia* sp. na *Cornus* spp. . . . *Zoophthora aphidis*, str. 211 (podrodz. *Zoophthora*)

7. Średnica przetrwalników 14-20 µm . . . . . *T. cyrtoneurae*, str. 259
7*. Średnica przetrwalników 30-35 µm . . . . . *T. calliphorae*, str. 257

8. Przetrwalniki nie zabarwione o średnicy 25-35 µm, z episporium na powierzchni delikatnie dołkowato punktowanym; w muchówkach (*Diptera*) . . . . . *T. subpunctulatum*, str. 267
8*. Przetrwalniki zabarwione 9

9. Barwy przetrwalników jasne, raczej jaskrawe, od żółtej, pomarańczowej do bladobrunatnawej w masie 10
9*. Barwy przetrwalników ciemne, od orzechowej przez brunatną do prawie czarnej 12

10. Przetrwalniki jaskrawożółte, kuliste do szeroko elipsoidalnych, 26-48 x 24-32 µm, o ścianie 1-1.5 µm grubej, i powierzchni brodaweczkowatej; w poczwarkach *Cimbex* sp. (*Hymenoptera: Cimbicidae*) . . . . . *T. cimbicis*, str. 258

10*. Przetrwalniki kuliste, jasno- brunatnawożółte lub żółtopomarańczowe, o silnie kolczastym lub gęsto stożkowato brodawkowanym episporium . 11

11. Przetrwalniki o średnicy 30-50 µm, ze stożkowatymi, tępymi brodawkami na episporium; na muchówkach z rodziny *Lauxaniidae* . . . . . *Zoophthora echinospora,* str. 185 (podrodz. *Neopandora*)

11*. Przetrwalniki o średnicy 25-30 µm; episporium kolczaste; w larwach i poczwarkach *Bothynoderes punctiventris* . . . . . *T. cleoni*, str. 259

12. Przetrwalniki w masie orzechowe lub brunatne 13

12*. Przetrwalniki w masie czarne lub brunatnoczarne; występujące pojedynczo mogą być ciemnobrunatne 16

13. Przetrwalniki orzechowe (brunatne z zielonym odcieniem), kuliste lub nieznacznie owoidalne, 36-40 µm, episporium 2.5 µm grubości porysowane nieregularnymi rowkami; w gąsienicach *Eurois occulta (Lepidoptera: Noctuidae).* . . . . . *T. lavrovium*, str. 262

13*. Przetrwalniki brunatne bez orzechowo-zielonawego odcienia 14

14. Przetrwalniki kuliste, kulistawe lub gruszkowate o dłuższej średnicy 35-56 µm; episporium brodawkowate; ryzoidy wiązkowate; w nieokreślonych chrząszczach (*Coleoptera*) . . . . . *T. coleopterorum*, str. 259

14*. Przetrwalniki zazwyczaj kuliste, wyjątkowo pojedyncze nieznacznie gruszkowate 15

15. Episporium gładkie; średnica przetrwalników 41-48 µm, z dwiema delikatnymi rysami wzdłuż „strefy równikowej"; w gąsienicach *Autographa gamma (Noctuidae)* . . . . . *T. inexspectatum*, str. 261

15*. Episporium brodawkowate; średnica przetrwalników 35-40 um; w gąsienicach *Cerastis satellitia (Noctuidae)*; ciało gospodarza "rozlewa się po śmierci" . . . . . *T. dissolvens*, str. 260

16. Episporium kolczaste; średnica przetrwalników 38-45 µm; w mszycach . . . . . *T. atrospermum*, str. 256

16*. Episporium prawie gładkie lub inaczej urzeźbione 17

17. Przetrwalniki kuliste lub kulistawe, 28-46 µm 18

17*. Przetrwalniki kuliste, kulistawe lub spłaszczone, o największej średnicy 36-61 µm 20

18. Episporium grubo brodawkowate lub pofałdowane, 3-4 µm grube;

przetrwalniki o średnicy 35-45 µm; w gąsienicach *Barathra brassicae (Noctuidae)* . . . . . *T. bereshkoveanum*, str. 257

18*. Episporium gładkie, delikatnie brodawkowane lub płytko dołkowane 19

19. Przetrwalniki o średnicy 28-46 µm z dwuwarstwowym episporium 4.5-7 µm grubym, o powierzchni gładkiej lub delikatnie szorstkiej; w larwach *Zabrus gibbosus (Carabidae)* . . . . . *T. jaczewskii*, str. 262

19*. Przetrwalniki o średnicy 28-37 µm, delikatnie szorstkie lub tylko nierówno dołkowato punktowane; w larwach *Phytonomus* spp. (*Coleoptera: Curculionidae)* . . . . . *T. punctatum*-complex, str. 269

20. Przetrwalniki przypłaszczone, ciemnobrunatne z granulkowatą powierzchnią episporium; w gąsienicach niektórych rolnic (*Noctuidae: Agrotinae)* . . . . . *Zoophthora gammae*, str. 167

20*. Przetrwalniki kuliste lub subowoidalne, nie przypłaszczone. 21

21. Przetrwalniki kremowe lub płowo-żółte o średnicy 41-49 µm, z czarnymi brodawkami nieregularnie rozrzuconymi po episporium; w komarnicach (*Diptera: Tipulidae)* . . . . . *T. porteri*, str. 263

21*. Przetrwalniki dołkowane lub rzeźbione rysami; w gąsienicach sówek (*Lepidoptera: Noctuidae*) 22

22. Przetrwalniki o średnicy 46-61 µm z okrągłymi płytkimi, dołkami na episporium; w gąsienicach *Barathra brassicae (Noctuidae)* . . . . . *T. pustulatum*, str. 264

22*. Przetrwalniki zasadniczo kuliste o średnicach 36-55 µm, pojedyncze o nietypowych kształtach gruszkowatych lub wydłużonych do 100 x 30 µm; episporium porysowane nieregularnymi bruzdami . . . . . *T. megaspermum*, str. 255

23. Przetrwalniki drobne, ich średnica tylko wyjątkowo przekracza 12 µm 24

23*. Średnica przetrwalników normalnie przekracza 14 µm, zwykle znacznie większe 26

24. Przetrwalniki kuliste lub szeroko-owoidalne, przeźroczyste, z bezbarwnym gładkim episporium; w deutonimfie *Eremaeus oblongus* . . . . . *T. hyalinum*, str. 261

24*. Przetrwalniki przydymione lub jasnobrunatne dzięki ciemno zabarwionej, delikatnie szorstkiej powierzchni episporium 25

25. Przetrwalniki o średnicy 9-12 µm, najczęściej 10.5-11 µm, o błonach 1.7-2.3 µm grubych, jednolicie delikatnie szorstkich; liczba jąder nieznana; w *Pergamasus* sp . . . . . *T. pusillum*, str. 264

25*. Przetrwalniki jednojądrowe o średnicy 8-10 µm, najczęściej 8.4-9.2 µm; szorstkość episporium w postaci koncentrycznych stref; w *Trichouropoda szczecinensis*. . . . . *T. monokaryoticum*, str. 262

26. Średnice przetrwalników mieszczą się w przedziale 14-20 µm, wyjątkowo pojedyncze zarodniki mogą być nieco większe 27
26*. Średnice przetrwalników regularnie przekraczają 20 µm 31

27. Episporium cienkie, poniżej 1 µm grubości 28
27*. Episporium o grubości większej niż 1 µm 29

28. Wielkość przetrwalników bardzo stała 15.5-16 µm średnicy, zupełnie wyjątkowo o 2-3 µm większe; episporium około 0.5 µm grube; w roztoczu z grupy *Parasitiformes*. . . . . *T. tatricum*, str. 268
28*. Wielkości zarodników zróżnicowane w granicach 9-23 µm średnicy, najczęściej 14.5-16 µm, episporium około 1 µm grube; w roztoczu z grupy *Oribatida* . . . . . *T. tenuiparietatum*, str. 268
29. Przetrwalniki ciemne, brunatno-czarne lub smolisto-czarne, o średnicy 16-20 µm, z szorstkim, brodawkowanym i kolczastym episporium 3-4 µm grubym; w *Pergamasus* sp . . . . . *T. fumosonigrum*, str. 260
29*. Przetrwalniki bezbarwne, gładkie 30

30. Przetrwalniki głównie kulistawe o średnicy 11.4-23 µm, najczęściej 17-19 µm, pojedyncze elipsoidalne lub gruszkowate 18-26 x 13-17 µm; w *Trachyuropoda coccinea* . . . . . *T. sphaericum*, str. 266
30*. Przetrwalniki regularnie kuliste o średnicy 15.5-19 µm, rzadko 2-3 µm większe; w roztoczach z grupy *Gamasida* . . . . . *T. svalbardense*-complex, str. 267
31. Episporium gładkie lub bardzo delikatnie szorstkie 32
31*. Episporium szorstkie lub inaczej ornamentowane 36

32. Cienka powierzchniowa warstewka episporium sciemniała lub brunatna nadaje przetrwalnikom wygląd przydymiony; ich kształt regularnie kulisty lub subsferyczny 33
32*. Przetrwalniki bezbarwne lub jaskrawo żółte, bez ściemniałego odcienia, ich kształty od kulistych do elipsoidalnych 34
33. Przetrwalniki kuliste o średnicy (17-) 21-26 (-28.5) µm, nieco przydymione, z episporium 2.5-4 µm grubym o powierzchni delikatnie szorstkiej; w *Oplitis alophora* . . . . . *T. oplitidis*, str. 263
33*. Przetrwalniki kuliste lub subsferyczne o średnicy (32-) 36-38 (-44) µm grubym; w *Pergamasus* sp . . . . . *T. distinctum*, str. 260

34. Przetrwalniki regularnie kuliste o średnicy 20-30 µm, wyjątkowo owoidalne lub gruszkowate, 30-32 x 22-27 µm, z episporium 5-6 µm grubym; w *Trachyuropoda coccinea*. . . . . *T. uropodinis*, str. 269

34*. Przetrwalniki zazwyczaj owoidalne, szeroko-elipsoidalne lub subsferyczne, rzadko regularnie kuliste, o episporium 1.5-2.5 µm grubym . . 35

35. Dłuższe średnice owoidalnych lub elipsoidalnych przetrwalników 20-30 µm, subsferycznych 23-25 µm; układ przetrwalników łańcuszkowaty, a ich zawartość grubo ziarnista, jaskrawo-żółta; w *Pergamasus* sp . . . . . *T. subglobosum*, str. 267

35*. Dłuższe średnice przetrwalników w granicach (20-) 30-35 (-40) µm; przetrwalniki tworzą się pojedynczo z odseperowanych ciał strzępkowych, ich zawartość drobnoziarnista, szara; w *Pergamasus brevicornis* . . . . . *T. azygosporicum*, str. 257

36. Episporium jednolicie szorstkie, bez powyginanej falistej linii obrysu powierzchni przetrwalników 37

36*. Episporium płyko dołkowane dające w obrysie przetrwalników mniej lub bardziej gęsto powyginaną linię z mniej regularnymi, większymi płaskimi lub słabo zaklęslymi polami 39

37. Przetrwalniki jasno-żółte o średnicy ca 22-23 µm, z episporium 2-3 µm grubym, o powierzchni nie przeciemnionej, nierówno szorstkiej; w roztoczu z rodziny *Galumnidae* . . . . . *T. verruculosum*, str. 269

37*. Powierzchniowa warstwa episporium wyraźnie ściemniała, przydymiona 38

38. Przetrwalniki kuliste 25-32 µm, najczęściej 26-30 µm, z zawartością bezpostaciową warstwowaną koncentrycznie; powierzchnia episporium delikatnie szorstka; w *Pergamasus* sp. . . . . *T. slovienense*, str. 266

38*. Przetrwalniki kuliste, 22-27 µm, oraz owoidalne 24-29 (-35) x 18-23 (-26.5) µm, z zawartością równomiernie granulkowatą; episporium wyraźnie szorstkie; w *Veigaia* sp. . . . . *T. silesianum*, str. 265

39. Przetrwalniki w zarysie tępo-wielokątne o średnicy 22-32 µm, najczęściej 27-28.5 µm, z nieregularnymi rysami i płaskimi lub zaklęsłymi półkami na powierzchni episporium; w *Uropoda minima* . . . . . *T. obtusoangulatum*, str. 263

39*. Powierzchnia przetrwalników pokryta regularnie płytkimi dołkami o łagodnie obłych brzegach, dającymi w zarysie falistą linię 40

40. Przetrwalniki zazwyczaj o średnicy 29-35 µm, niezwykle gęsto dołkowane, sprawiające wrażenie nieco szorstko punktowanej powierzchni; w różnych roztaczach z grupy *Gamasida* . *T. tenuisculpturatum*, str. 268

40*. Przetrwalniki zazwyczaj o średnicy 33-34 µm, z większymi, wyraźnie oddzielonymi, okrągłymi zagłębieniami na episporium; w *Pergamnasus* sp. . . . . *T. acaricolum*, str. 256

GLOSSARY

acropleurogenous — related to conidiogenous cells or conidia of representatives of the family *Meristacraceae* — borne laterally in subapical part of the conidophore and terminate its main axis.

ahaptospore — a non-adhesive capilliconidium, devoid of external viscous cover or terminal gluey haptor (see p. 25).

anemochory — transmisson of spores by wind or air currents.

autochory — dispersal of reproductive units by particular mechanisms or structures, like violent ejection of spores, external structures on spore wall allowing to replace etc.

azygospore — a resting spore analogous to zygospore produced without precedent conjugation (see p. 15).

ballistospore — a spore actively projected at its maturity by the specific mechanism, occurring in some *Uredinales*, *Tilletiaceae* and *Sporobolomycetes*.

ballospore — a reproductive unit ejected thanks to oppositely directed osmotic pressure in the spore and sporogenous cell (see p. 19).

binucleate — see „dikaryotic".

bitunicate — related to wall structure of the conidia — distinctly two-layered, with layers easily separable.

capilliconidium — type of secondary spore produced on long and very thin sporophore protruding from a primary conidium or resting spore (see p. 24).

capilliphore — thin and long sporophore, protruding from a conidium or resting spore, bearing a capilliconidium at end.

capillispore — see „capilliconidium".

cryptobitunicate — related to external wall structure of hyphae or conidia composed two hardly separable layers of different optical density (p. 20).

distal — end of conidium or sporophore polarly opposite to the base.

dikaryotic — a spore or a cell of mycelium containing two nuclei („binucleate").

epispore — external layer of resting spore wall, often coloured and ornamented on the surface

foramen — a trace of maternal hyphae on the epispore of a resting spore.

haptor — an adhesive outgrowth on the distal end of a capilliconidium.

haptospore — capillispore furnished with an adhesive outgrowth (haptor) at the distal end (p. 24).

holdfast — terminal part of a rhizoid, widened, irregularly ramose or disc-like (appresorium-like), attaching host's cadaver to substrate.

hydrochory — transmission of spores by water.

loricoconidium — a conidium tranformed into a resting spore by wall thickening (p. 26).

microconidium — a secondary conidium originating in result or multiplicative resporulation, usually on short, sterigma-like sporophore.

monokaryotic — a cell or spore containing one nucleus („uninucleate").

monopodial — related to conidiophore branching — one-side series of conidiogenous cells produced successively in subapical part of the conidiophore.

multinucleate — see „polykaryotic".

mycose — a disease caused by fungal agent.

oligokaryotic — spore or cell containing few to about 25 nuclei ("paucinucleate").

papilla — thin-walled, unitunicate basal part of a primary or secondary ballospore, usually convex after ejection.

paucinucleate — see „oligokaryotic".

polykaryotic — a cell of mycelium or spore containing great number of nuclei (in cases of entomophthoralean fungi several dozen to over a hundred) (multinucleate).

prohaptospore — an adhesive capillispore covered by viscous substance on all surface (p. 24).

proximal — polarly the closest to the base, basal.

pseudocystidium — a conical or needle-like hypha perforating host's cadaver cuticle and sticking out over the conidiogenous layer on its surface (p. 27).

pseudorhizomorph — a compact fsciculate aggregation of rhizoids (p. 26).

resporulation — production of secondary spores.

rhizoids — sterile hyphae perforating ventral side of a host and attaching its body to the substrate (p. 26).

secondary conidium — a conidium originating from the maternal one, usually on short, tubular sporophore or on the capilliphore (p. 21).

sternal — situated on the ventral side of host's body.

tetrakaryotic — cell or spore containing four nuclei.

tetraradiate — related to conidia of some entomophthoralean species of aquatic habitats — producing 2-4 radiately protruding outgrowths (p. 24).

uninucleate — see „monokaryotic".

zoochory — transmission of reproductive units by animals.

zygospore — unicellular resting spore of strongly thickened wall, produced after zygogamy.

INDEX OF LATIN NAMES

(Names of fungi in italics; numbers in heavy type [boldface] indicate page of the description)

Acalyptrata 98,
acanthopygia L., Chelidurella 215, 229,
acaricida Petch, *Empusa* 134,
acaricolum Bałazy et Wiśniewski, *Tarichium* 255, **256**, 327,
acaridis Petch, *Empusa* 142,
acaridis (Petch) Milner, *Neozygites* 135, **142,** 309,
Acarina 34, 40, 65, 75, 134, 143, 196, 288, 308, 314,
Acer pseudoplatanus L. 180,
acerosum (Schrank) Ehrenberg et Ralfs, Closterium 59,
acrea (Drury), Estigmene 119,
Acridiidae 116
Acyrtosiphon kondoi Shinji 174, 196, 317,
— pisum (Harris) 74, 79, 102, 176, 196,
Adephaga 237,
Adoristes ovatus (C. L. Koch) 92,
Adelphocoris 304,
— lineolatus (Goeze) 96, 100,
adiaeretus Drechsler, *Conidiobolus* 295
adjarica Tsintsadze et Vartapetov, *Entomophthora* 142, 143,
adjarica (Tsintsadze et Vartapetov) Remaud. et Keller, *Neozygites* 142,
Aegopodium podagraria L. 176,
Agriotes 206, 210, 321.
— lineatus L. 210,
— obscurus L. 210,
— sputator L. 210, 236
— ustulatus Schall. 210,
Agrotinae 161, 165, 170, 252, 313, 325
Agrotis segetum (Denis et Schiff.) 167, 255, 256,
albicilla (L.), Heliaeetus 269,
albomarginatus (DeGeer), Chorthippus 116,
aldrichi Parker, Sarcophaga 179,
Aleurodes 177,
Aleurodidae 316, 317,
aleurodis Bałazy et Manole, *Zoophthora* 175, **176,** 317,
alophora (Berlese), Oplitis 254, 263, 326,
althae Hanstein, Tetranychus 143,
americana (Thaxter) Bałazy ex Humber, *Zoophthora* **162,** 163,
americana (Thaxter) Batko, *Zoophthora* **162**, 173, 314, 315
americana Thaxter, *Empusa* 162,
americana (Thaxter) Humber, *Furia* 162,
americana (Thaxter) Remaud. et Keller, *Erynia* 162,
americanum (Fabr.), Malacosoma 165,
Amphoromorpha Thaxter 25,
Amphorophora rubi (Kaltenbach) 176,
Amphipyra pyramidea L. 170,
Ancylistaceae 11, 22, 26, 30, 35, 36, 43, 50, 51, **57,** 86, 94, 269, 284, 286, 287, 289, 292, 293, 302,
Ancylistes Pfitzer 18, 26, 31, 32, 35, 36, 49, 57, **58,** 283,
Ancylistes
— *berdani* Sparrow 60,
— *closterii* Pfitzer 58, **59,** 294,
— *netrii* Couch **59,** 294,
— *pfeifferi* Beck 58, **60,** 294,
anglica (Petch) Ben-Ze'ev, *Erynia* 209,
anglica Petch, *Enthomophthora* 193, 198, 201, 209,
anglica (Petch) Humber, *Zoophthora* 37, 38, 203, 206, **209,** 237, 250, 321,
anhuiensis Li, *Erynia* 211,
anhuiensis (Li) Humber, *Zoophthora* 20, **211,** 318,
annuum L., Capsicum 105,
Anoecia 216, 251, 323,
— corni 176,
Anomala rufiventris Redt. 174, 179, 316,
Anthomyiidae 108, 144, 150, 159, 304, 309, 312,
Anthomyzidae
anticae Reihardt ex Michell, *Empusa* 117,
Aphidae 135, 137, 243, 245, 318,
aphidis Hoffmann in Fres., *Entomophthora* 176, 195, 211, 216,

aphidis (Hoffmann in Fres.) Humber et Ben-Ze'ev, *Erynia* 211,
aphidis (Hoffman in Fres.) Cohn, *Tarichium* 211,
aphidis (Hoffmann in Fres.) Batko, *Zoophthora* 176, 211, 240, 322,
aphidis (Hoffmann in Fres.) Remaud. et Hennebert, *Zoophthora* 207, **211,** 212, 216, 251, 323,
aphidis Witlaczil, *Neozygites* 136,
Aphidoidea 288, 309,
Aphis 156,
— citricola v.d. Goot 243,
— fabae Scopoli 79, 102, 136, 176, 195,
— frangulae Kaltenbach 102, 176,
— nasturtii Kaltenbach 176,
— umbrella Börner 174, 195, 31
aphrophorae Rostrup, *Entomophthora* 239,
apiculata (Thaxter) Batko, *Culicicola* 107
apiculata Thaxter, *Empusa*, var. *major* 107, 108,
apiculata Thaxter, Empusa subg. *Entomophthora* 107
apiculata (Thaxter) Gustafsson, *Entomophthora* 107, 288,
apiculata (Thaxter) Humber, *Batkoa* 35, 38, 39, 61, **107,** 108, 112, 168, 305,
apiculata (Thaxter) Lakon, *Lamia* 107,
apiculata (Thaxter) Lakon, *Lamia*, var. *major* 107,
apiculatum Couch, *Septobasidium* 78,
apiculatus (Thaxter) Remaud. et Keller, *Conidiobolus* 107, 108, 168
aquatica Anderson et Ringo, *Entomophthora* 152,
aquatica (Anderson et Ringo ex Anderson et Anagnostatis) Humber, *Erynia* 152,
aquatica (Anderson et Ringo) Bałazy, *Zoophthora* 38, 150, **152,** 311,
aquatica (Anderson et Ringo) Remaud. et Hennebert, *Erynia* 152,
Arachnida 40,
Arachnoidea 306,
Arctiidae 118, 119, 123, 164, 313,
Arge berberidis Schrank 204, 218, 319,
— melanochroa Gmelin 108,
Argidae 108, 218, 319,
arginis Bałazy, *Zoophthora* 16, 204, 214, **217,** 319,
armigera Hübner, Heliothis 119,
arrenoctona Giard, *Entomophthora* 132,
Ascomycotina 37,
Aschiza, Cyclorrhapha 98,
asiatica Humber, Soper et Shimazu, *Entomophaga* 117,
asiaticum (Nevsky), Impatientium 74, 102, 176, 242,
Asphondylia 108,
asterospermum Drechsler, *Meristacrum* 32, **89,** 301,
Athalia rosae L. 175, 178, 317,
athaliae Keller, *Erynia* 177,
athaliae (Keller) Bałazy, *Zoophthora* 175, **177,** 317,
Atylotys thoracicus (Heine) 125,
atrosperma Petch, *Entomophthora* (*Tarichium*) 256,
atrospermum (Petch) Bałazy, *Tarichium* 252, **256,** 324,
Auchenorrhyncha 108, 185, 205, 304, 316, 321,
Aulacorthum solani (Kaltenbach) 102, 176,
aulicae Reihardt in Bail, *Empusa* 114, 117,
aulicae (Reihardt in Bail) Humber, *Entomophaga* 37, 38, 39, 307,
aulicae (Reihardt in Bail) Sorokin, *Entomophthora* 117,
auricularia (L.), Forficula 162, 166, 175, 229, 314, 318,
aurita L., Ledra 108,
Autographa gamma (L.) 167, 252, 261, 324,
autumnalis Bałazy, *Zoophthora* 38, 203, 213, **218,** 318,
autumnalis L., Tabanus 90,
avellana L., Corylus 137,
avenae (Fabr.), Sitobion 102, 119, 176,
azygosporicum Bałazy, Wiśniewski et Kaczmarek, *Tarichium* 254, **257,** 327,
Ballocephala Drechsler 18, 19, 21, 22, 26, 30, 32, 88, **90,** 286, 301,
— *pedicellata* Pohlad et Bernard 90, **91,** 301,
— *sphaerosperma* Drechsler 17, 90, **91,** 301,
— *verrucospora* Richardson **91,** 301,
bangalorensis Srinivasan et Thirum. *Conidiobolus* 295,
banksi (Mc Gregor), Eutetranychus 143,
Barathra brassicae (L.) 252, 253, 257, 265, 325,
Basidiobolaceae 11, 30, 35, 50, **51,** 94, 284, 292, 293,
Basidiobolus Eidam 11, 12, 19, 21, 22, 23, 24, 25, 30, 49, **52,** 284, 285, 286, 287, 290, 293,
— *haptosporus* Drechsler 52, 54, **55,** 56,
— *haptosporus* var. *major* Srinivasan et Thirum. 293,
— *heterosporus* Srinivasan et Thirum. 54,
— *magnus* Drechsler 55,
— *meristosporus* Drechsler 52, **55,** 56, 293,
— *microsporus* Benjamin 15, 23, 25, 52, 55, **56,** 293,

— *myxophilus* Fr. 54,
— *ranarum* Eidam 6, 14, 16, 17, 38, 39, **52,** 53, 55, 57, 263, 293,
Basidiomycetes 18, 34, 82,
Batkoa Humber 19, 35, 61, 95, **106,** 114, 303, 305,
— *apiculata* (Thaxter) Humber 35, 38, 39, 61, **107,** 112, 168, 305,
— *dysderci* (Viegas) Humber 106, 107, **109,** 286, 305,
— *gigantea* (Keller) Humber 107, **109,** 305,
— *major* (Thaxter) Humber 13, 39, 61, 107, **110,** 111, 305,
— *papillata* (Thaxter) Humber 107, **112,** 305,
batkoi (Bałazy) Keller, *Entomophaga* 38, 115, **128,**
batkoi Bałazy, *Entomophthora* 128,
batkoi (Bałazy) Remaud. et Keller, *Conidiobolus* 128,
berdani Sparrow, *Ancylistes* 60,
bereshkoveanum Lavrov et Smirnova, *Tarichium* 252, **257,** 325,
bereshkoveana Lavrov et Smirnova ex MacLeod et Müller-Kögler, *Entomophthora* (*Tarichium*) 257,
berberidis Schrank, Arge 204, 218, 319,
Betula populifolia Marsh. 137,
bialoviezensis Bałazy, *Zoophthora* 38, 206, 213, 215, **219,** 222, 224, 322,
Bibio marci L. 241,
Bibionidae 241,
biconica Walker, Dicercoprocta 146,
biguttatus (L.), Chorthippus 116,
blackwalli Meade, Leiobunum 130,
Blattodea 37,
blunckii (Lakon) Batko, *Zoophthora* 175, 177, **178,** 318,
blunckii Lakon, *Entomophthora* 178,
blunckii (Lakon ex G. Zimmermann) Bałazy ex Humber, *Zoophthora* 175, 177, **178,** 318,
blunckii Lakon ex G. Zimmermann, *Entomophthora* 178,
blunckii (Lakon ex G. Zimmermann) Humber, *Pandora* 178,
bonaerensis (Berg), Dorisiana 146,
Bothynoderes punctiventris (Germar) 259, 324,
Boudierella coronata Costantin 78,
Braconidae 183, 317,
Brachycera 96, 159, 161, 313, 315, 320,
Brachycaudus cardui (L.) 176,
Brahmina sp. 174, 179, 316,
brahminae (Bose et Mehta) Batko, *Zoophthora* 174, **178,** 316,
brahminae Bose et Mehta, *Entomophthora* 178,
brahminae (Bose et Mehta) Remaud. et Hennebert, *Erynia* 178,
brahminae (Bose et Mehta) Humber, *Pandora* 179,
Brassica rapa L. 105,
brassicae Bouche, Hylemya (Delia) 104, 176, 257,
brassicae L., Barathra 257, 265, 325,
brassicae (L.), Brevicoryne 72, 74, 102, 136, 252,
brassicae L., Pieris 205, 208, 209, 320,
brefeldianus Couch, *Conidiobolus* **78,** 299,
Brevicoryne brassicae (L.) 72, 74, 102, 136, 176,
brevicornis (Berlese), Pergamasus 254, 257,
brevinucleata Keller et Wilding, *Entomophthora* 39, 97, 304,
brevispora Bałazy, *Zoophthora* 39 , 204, 215, **221,** 319,
brumata L., Cheimatobia 220,
brunneus (Thunberg), Chorthippus 116,
Bryobia 143,
Bufo bufo L. 54,
bullata (Thaxter et MacLeod in Humber) Bałazy ex Humber, *Zoophthora* 172, **179,** 180, 315,
bullata Thaxter et MacLeod in Humber, *Erynia* 179,
bullata (Thaxter et MacLeod in Humber) Humber, *Pandora* 179,
bullata Thaxter in Povah, *Entomophthora* 179,
bullata (Thaxter in Povah) Remaud. et Hennebert, *Erynia* 179,
bursanius L., Pemphigus 195, 317,
caesar L., Lucilla 162,
calceolariae Maskell, Pseudococcus 83, 298,
Calliphora 162, 314,
Calliphora erythrocephala Meigen. 201,
— vomitoria L. 162, 201, 258,
— vomitoria var. dunensis Giard 194,
calliphorae Giard, *Entomophthora* 194, 257,
calliphorae Giard ex MacLeod et Müller-Kögler, *Entomophthora*, (*Tarichium*) **257,**
calliphorae (Giard) *Tarichium* 37, 251, 323,
Calliphoridae 97, 121, 152, 153, 173, 179, 201, 304, 315,
calopteni Bessey, *Entomophthora* 31, 117,
calopteni (Bessey) Humber, *Entomophaga* 116, 117, 307,
calopteni Bessey ex MacLeod et Müller-Kögler, *Entomophthora* (*Tarichium*) 117,
Caloptenus differentialis (Thomas) 117,
Calyptrata 98, 205, 306, 314, 315,
canadensis MacLeod, Tyrrell et Soper, *Entomophthora* 222,

canadensis (MacLeod, Tyrrell et Soper) Humber et Ben-Ze'ev, *Erynia* 222,
canadensis MacLeod, (Tyrrell et Soper) Remaud. et Henneb., *Zoophthora* 205, 216, **222,** 321,
Cantharidae 130, 131, 173, 265, 316, 322, 323,
Cantharis
— livida L. 193,
— rustica Fallen 193,
Capillidium Ben-Ze'ev et Kenneth, *Conidiobolus*, subg. 24, 25, 62, **83,** 294, 299,
Capitophorus similis v.d. Goot 74, 102, 176, 242, 243,
Capsicum annuum L. 105,
Carabidae 170, 173, 252, 262, 313, 315, 325,
cardui (L.), Brachycaudus 176,
carinatus Berlese, Dinychus 267,
Carineta 146,
carinetae Soper, *Massospora* 146
carnosum Buckton, Microlophium137,
caroliniana Thaxter, *Empusa* 131,
caroliniana (Thaxter) Humber, *Eryniopsis* 20, 22, 39, 54, **131,** 132, 308,
caroliniana (Thaxter) Remaud. et Hennebert, *Erynia* 131,
caroliniana Thaxter ex Keller, *Entomophthora* 131, 210,
carpentieri Giard, *Entomophthora* subg. *Lophorhiza* 210, 236
cassini (Fisher), Magicicada 146,
castrans Batko et Weiser, *Strongwellsea* **144,** 306,
castrans (Batko et Weiser) Remaud. et Keller, *Erynia* 144,
cassyapae (Distant), Paharia 146,
Casuarina equisetifolia L. 73,
Cecidomyiidae 99, 304, 305,
Celypha flavipalpana Herrich-Schäffer 224, 322,
Cephalosporium 231,
Cerastis satellitia (L.) 252, 260, 324,
Cercopidae 244,
cercopidis Keller, *Conidiobolus* 35,
Chauliognathus pennsylvanicus De Geer 130, 131, 307,
Cheimatobia brumata (L.) 220,
Chelidurella acanthopygia L. 215, 229,
chlamydosporus Drechsler, *Conidiobolus* 79, 298,
chlapowskii Bałazy, Wiśniewski et Kaczmarek, *Conidiobolus* 297,
Chorthippus albomarginatus (DeGeer) 116,
— biguttatus (L.) 116,
— brunneus (Thunberg) 116,
— dorsatus (Zetterstedt) 116,
— mollis Charp. 116,
chromaphidis (Burger et Swain) Batko, *Culicicola* 102,
chromaphidis Burger et Swain, *Entomophthora* 102, 103,
Chrysomelidae 108, 316,
Chrysops relictus Meigen 90,
chrysorrhoea (L.), Euproctis 118,
Chytridiales 256,
Cicadellidae 171, 251, 262, 323,
Cicadetta 146,
— murrayiensis Distant 146,
— puer Walker 146,
cicadettae, Soper, *Massospora* 146,
cicadina, Peck, *Massospora* 145, 146,
Cicadoidea 108,
Cimbex 251, 258, 324,
Cimbicidae 251, 324,
cimbicis Bubak, *Entomophthora* 258,
cimbicis (Bubak) Lakon, *Tarichium* 251, **258,** 324,
cimbicis Bubak ex MacLeod et Müller-Kögler, *Entomophthora* (*Tarichium*) 258,
cinetifera, Diceroprocta 146,
— viridicosta Davis, Diceroprocta cinetifera, var. 146,
cirsii (L.), Uroleucon 74, 103, 176,
citri (Risso), Phenacoccus 139, 143,
cleoni (Wize) Bubak ex MacLeod et Müller-Kögller, *Entomophthora (Tarichium)* 259,
cleoni (Wize) Lakon, *Tarichium* 251, **259,** 324,
cleoni Wize, *Massospora* 259,
Cleonus punctiventris (Germar) 251,
closterii Pfeiffer, *Ancylistes* 58, **59,** 294,
Closterium 58, 60, 294,
Closterium acerosum (Schrank) Ehrenberg et Ralfs 59,
clypeatus Meigen, Platycheirus 104,
Coccoidea 308,
coccinea (Michael), Trachyuropoda 253, 254, 266, 269, 326,
Coelomomyces milkoi Dudka et Koval 90,
cohni Lebert, *Myiophyton* 98,
colei Alexander, Tipula triplex 264,
Coleoptera 34, 37, 108, 110, 115, 123, 130, 170, 173, 179, 206, 249, 251, 259, 262, 265, 315, 319, 321, 322, 324, 325,
coleopterorum (Petch) Bałazy, *Tarichium* 252, **259,** 324,
coleopterorum Petch, *Entomophthora (Tarichium)* 236, 237, 259,
Collembola 155,
colorata Sorokin, *Entomophthora* 116,
complens Lohde 18, 32, 33,

Completoria Lohde 18, 32, 33, 36, 94, **112,** 287, 302,
— *complens* Lohde 31, **113,**
Completoriaceae 35, 50, 94, 113, 305,
conglomerata (Sorokin) Brumpt, *Empusa* 119,
conglomerata Sorokin, *Entomophthora* 119,
conglomerata (Sorokin) Keller, *Entomophaga* 119, 306,
conglomeratus (Sorokin) Remaud. et Keller, *Conidiobolus* 119,
conica (Nowakowski) Batko, *Zoophthora* 13, 38, 150, **154,** 156, 159,
conica Nowakowski, *Entomophthora* 154,
cinica Nowakowski ex Thaxter, *Empusa* 154,
conica (Nowakowski) Remaud. et Henneb., *Erynia* 154,
Conidiobolus Ben-Ze'ev et Kenneth, *Conidiobolus* subg. **62,** 294,
Conidiobolus Brefeld 6, 17, 21, 22, 23, 24, 25, 26, 30, 31, 32, 33, 34, 35, 38, 39, 58, **60,** 61, 76, 86, 106, 114, 286, 287, 290, 293, 294,
— *adiaeretus* Drechsler 63, **70,** 295,
— *apiculatus* (Thaxter) Remaud. et Keller 107, 168,
— *batkoi* (Bałazy) Remaud. et Keller 128,
— *bangalorensis* Srinivasan et Thirum. 63, **68,** 295,
— *brefeldianus* Couch 77, **78,** 299,
— *Capillidium* Ben-Ze'ev et Kenneth, subg. 24, 25, 62, **83,** 294, 299,
— *cercopidis* Keller 35, 168,
— *cercopis* Keller 168,
— *chlamydosporus* Drechsler 79, 298,
— *chlapowskii* Bałazy, Wiśniewski et Kaczmarek 65, **75,** 297,
— *Conidiobolus* Ben-Ze'ev et Kenneth, subg. 62, 294,
— *couchii* Srinivasan et Thirum. 63, **69,** 296,
— *coronatus* (Costantin) Batko 14, 20, 32, 64, 76, 77, **78,** 297, 299,
— *coronatus* (Costantin) Srinivasan et Thirum. 78,
— *conglomeratus* (Sorokin) Remaud. et Keller 119,
— *Delacroixia* (Sacc. et Syd.) Tyrrell et MacLeod, subg. 25, 62, 64, **75,**, 294, 296, 297, 298,
— *denaeosporus* Drechsler 85,
— *destruens* (Weiser et Batko) Ben-Ze'ev 33, 61, 62, **65,** 295, 298,
— *eurymitus* Drechsler 63, **68,** 295,
— *eurypus* Drechsler 81,
— *firmipilleus* Drechsler 65, 77, **79,** 297,
— *giganteus* (Keller) Remaud. et Keller 109,
— *globuliferus* Drechsler 85,
— *gonimodes* Drechsler 79,
— *grylli* (Fres.) Remaud.et Keller 116,
— *gustafssoni* Bałazy 33, 37, 39, 62, **66,** 67, 288, 295,
— *heterosporus* Drechsler 83, **84,**
— *humicolus* Srinivasan et Thirum. 77, **80,** 298,
— *incongruus* Drechsler 77, **79,**
— *indicus* Srinivasan et Thrum. , *Conidiobolus megalotocus* var. 80,
— *inordinatus* Drechsler 85,
— *khandalensis* Srinivasan et Thirum. 63, **69,** 296,
— *lachnodes* Drechsler 64, **71,** 297,
— *lamprauges* Drechsler 64, **69,** 296,
— *lichenicolus* Srinivasan et Thirum. 72,
— *lobatus* Srinivasan et Thirum. 83, **84,** 300,
— *macrosporus* Srinivasan et Thirum. 77, **79,** 299,
— *major* (Thaxter) Remaud. et Keller 107,
— *megalotocus* Srinivasan et Thirum. 64, 65, 77, 79, 296, 297, 299,
— *minor* Brefeld 75,
— *multivagus* Drechsler 65, **73,** 297,
— *mycophagus* Srinivasan et Thirum. 81,
— *mycophilus* Srinivasan et Thirum. 76, **81,** 298,
— *nanodes* Drechsler 69,
— *nodosus* Sirinivasan et Thirum. 71,
— *obscurus* (Hall et Dunn) Remaud. et Keller 31, 37, 65, **73,** 137, 138, 297,
— *osmodes* Drechsler 32, 39, 64, **71,** 246, 269, 296,
— *papillatus* (Thaxter) Remaud. et Keller, 112,
— *parvus* Drechsler 70,
— *paulus* Drechsler 64, **70,** 296,
— *polyspermus* Drechsler 81,
— *polytocus* Drechsler 77, **82,** 299,
— *pseudococci* (Speare) Tyrrel et MacLeod 33, 76, **82,** 298,
— *pseudapiculatus* Keller 35,
— *pumilus* Drechsler 84, **85,** 300,
— *rhysosporus* Drechsler 84, **85,** 300,
— *rugosus* Drechsler 84,
— *stromoideus* Srinivasan et Thirum. 64, **72,** 296,
— *tenthredinis* (Fres.) Remaud. et Keller 126,
— *thromboides* Drechsler, 14, 33, 64, **72,** 296,
— *terrestris* Srinivasan et Thirum. 71,
— *undulatus* Drechsler 70,
— *utriculosus* Brefeld 60, 62, 64, **74,** 296,
— *villosus* Martin 78,
conspicuus Meigen, Rhagio 108, 192,
Contarinia pisi (Winn.) 99,

corni (Fabr.), Aneocia 176,
Cornus 216, 251, 323,
Cornus sanguinea L., 216,
coronata Costantin, *Boudierella* 78,
coronata (Costantin) Kevorkian, *Entomophthora* 78,
coronata (Costantin) Sacc. et Syd., *Delacroixia* 78,
coronatus (Costantin) Batko, *Conidiobolus* 14, 20, 32, 64, 76, 77, **78**, 297, 299,
cornucopioides (L. ex Fr.) Pers., *Craterellus* 72,
Corsidae 189,
coryli (Goetze), Myzocallis 137,
Corylus avellana L. 137,
couchii Srinivasan et Thirum., *Conidiobolus* 63, **69**, 296,
crassipes (L.), Pergamasus 142,
crassispora Bałazy, *Zoophthora* 38, 206, **223**, 229, 322,
crassitunicata (Keller) Humber et Ben-Ze'ev, *Erynia* 224,
crassitunicata Keller, *Zoophthora* 207, **224**, 323,
Craterellus cornucopioides (L. ex Fr.) Pers. 72,
Cratichneumon lanius Gravenhorst 234,
creatonoti (Yen in Humber) Batko, *Zoophthora* 161, **164**, 313,
creatonoti Yen in Humber, *Erynia* 164,
creatonoti (Yen in Humber) Humber, *Furia* 164,
creatonoti Yen, *Entomophthora* 164,
creatonotus Yen, *Entomophthora* 164,
creatonotus (Yen) Batko, *Zoophthora* 164,
Creatonotus gangis (L.) 161, 164, 313,
crustosa MacLeod et Tyrrell, *Entomophthora* 164, 165,
crustosa (MacLeod et Tyrrell) Humber et Ben-Ze'ev, *Erynia* 164,
crustosa (MacLeod et Tyrrell) Humber, *Furia* 164,
Cryptomyzus ribis (L.) 102, 176,
cucumeriformis Bałazy et Miętkiewski, *Neozygites* **140**, 141, 309,
Culex 119,
— pipiens L. 66, 152,
Culicidae 62, 66, 97, 99, 119, 150, 152, 154, 295, 311,
Culicicola Nieuwland 96,
— *apiculata* (Thaxter) Batko 107,
— *culicis* (A. Braun) Fres. 99,
— *chromophidis* (Burger et Swain) Batko 102,
— *virulenta* (Hall et Dunn) Batko 72,
culicis A. Braun, *Empusa* 99,
culicis (A. Braun) Fres., *Entomophthora* 39, 97, **99**, 101, 305,
culicis (A. Braun) Nieuwland, *Culicicola* 99,
culicis (A. Braun) Nowakowski, *Lamia* 99,
culicis (A. Braun) v. Arx, *Myiophyton* 99,
cunea Drury, Hyphantria 168,
cunicularis L., Fannia 144, 145, 310,
Curculionidae 174, 200, 206, 251, 259, 304, 316, 322, 325,
curvispora (Nowakowski) Batko, *Zoophthora* 38, 151, **154**, 155, 160, 312,
curvispora Nowakowski, *Entomophthora* 154,
curvispora (Nowakowski) Nowakowski ex Remaud. et Henneb. *Erynia* 154, 155,
Cyclorrhapha 304,
Cyclorrhapha Aschiza 98,
Cyclorrhapha Schizophora 98,
Cyrtoneura hortorum Meigen. 259,
cyrtoneurae Giard, *Entomophthora* 259,
cyrtoneurae Giard ex MacLeod et Müller-Kögler, *Entomophthora* (*Tarichium*) 251, 259,
cyrtoneurae (Giard), *Tarichium* **259**, 323,
decipens Loew, Lyciella 186,
Dacnusa 175, 183, 317,
dacnusae (Bałazy) Bałazy, *Zoophthora* 175, **183**, 317,
dacnusae Bałazy, *Erynia* 183,
defoliaria Cl., Hibernia 220,
Delacroixia Sacc. et Syd., 75,
Delacroixia (Sacc. et Syd.), Tyrrell et MacLeod, *Conidiobolus*, subg. 25, 62, 64, **75**, 298,
Delacroixia coronata (Costantin) Sacc. et Syd. 78,
delicata (Osborn), Diceroprocta 146,
Delphacidae 183, 244, 317,
delphacis (Hori) Bałazy ex Humber, *Zoophthora* 174, 180, **183**, 196, 310, 317,
delphacis Hori, *Entomophthora* 183,
delphacis (Hori) Humber, *Erynia* 183,
delphacis (Hori) Humber, *Pandora* 183,
delpiniana Cavara, *Entomophthora* 155,
delpiniana (Cavara) Bałazy, *Zoophthora* 150, **155**, 311,
delpiniana (Cavara) Humber, *Erynia* 155,
denaeosporus Drechsler, *Conidiobolus* 85,
Dereximyces lecanii Narasimhan et Thirum. 139,
Dermaptera 37, 162, 166, 205, 229, 314, 318, 321,
Desmidiaceae 31, 293,
Deschampsia flexuosa (L.) 68,
destruens Weiser et Batko, *Entomophthora* 61, 65,
destruens (Weiser et Batko) Ben-Ze'ev, *Conidiobolus* 33, 61, **65**, 295,
Deuteromycotina 37,

Diceroprocta biconica Walker 146,
— cinetifera 146,
— cinenifera var. viridicosta Davis 146,
— delicata (Osborn) 146,
diceroproctae Soper, *Massospora* 146,
Dicyphus pallidus Herrich-Schäffer 239,
differentialis (Thomas), Caloptenus 117,
differentialis (Thomas), Melanoplus 117,
digitus (Ehrenb.), Itzigsohn et Rothe, Netrium 294,
diminuta Soper, *Massospora* 146,
Dinychus carinatus Berlese 267,
Diphascon pinguis Marcus 92,
Diptera 34, 37, 90, 98, 99, 103, 107, 108, 110, 125, 130, 144, 145, 150, 155, 159, 161, 162, 169, 171, 172, 179, 185, 186, 191, 203, 206, 231, 235, 241, 252, 259, 264, 306, 308, 313, 314, 319, 320, 321, 323, 325,
Diprion 128,
— simile Hartig 126, 128, 129,
Diprionidae 116,
diprionis Bałazy, *Entomophaga* 38, 116, **126**, 129, 307,
dipterigena (Thaxter) Batko, *Zoophthora* 38, 39, 106, 172, **185**, 188, 192, 315,
dipterigena Thaxter ex Lakon, *Entomophthora* 185,
dipterigena (Thaxter) Humber, *Pandora* 185,
dipterigena (Thaxter) Remaud. et Hennebert, *Erynia* 185,
dirhodum (Walker), Metopolophium 176,
dispar (L.), Lymantria 119, 307,
dissolvens Vosseler, *Entomophthora* 260,
dissolvens Vosseler ex MacLeod et Müller-Kögler, *Entomophthora* (*Tarichium*) 260,
dissolvens (Vosseler) Lakon, *Tarichium* 252, **260**, 324,
disstria (Hübn.), Malacosoma 165,
distinctum Bałazy, Wiśniewski et Kaczmarek, *Tarichium* 254, **260**, 326,
Dolerus 126,
domestica Keller, *Entomophaga* 107, 108,
domestica L., Musca 98, 162, 171,
domestica (Packard), Thermobia 79,
Dorisiana bonaerensis (Berg) 146,
— semilata (Walker) 146,
dorisianae Soper, *Massospora* 146,
dorsatus (Zetterstedt), Chorthippus 116,
Drepanosiphum platanoidis (Schrank) 102, 176,
Drepanothrips reuteri (Uzel.) 135, 141, 142, 309,
Drosophilidae 98,
Dryomyzidae 203, 318,
dujardini (Doyere), Hypsibius 87, 92,
dysderci Viegas, *Empusa* 109,
dysderci (Viegas) Humber, Batko 106, 107, **109**, 286, 305,
dysderci (Viegas) MacLeod et Müller-Kögler, *Entomophthora* 109,
Dysdercus 107, 109, 305,
echinospora (Thaxter) Batko, *Zoophthora* 16, 38, 145, 172, 179, **185**, 186, 187, 314, 324,
echinospora Thaxter, *Empusa* 185,
echinospora (Thaxter) Humber, *Pandora* 185,
echinulatus Miura, *Zygnemomyces* **92**, 301,
Ectobius lapponicus DeGeer 62, 66, 67, 68, 295,
egressa MacLeod et Tyrrell, *Entomophthora* 31, 117,
Elater 236,
Elateridae 206, 210, 321,
elateridiphaga (Turian) Ben-Ze'ev et Kenneth, *Zoophthora* 209, 210, 237, 250,
elateridiphaga Turian, *Entomophthora* 193,
elateridiphaga Turian, *Entomophthora sphaerosperma* Fres., ssp. 209,
elateridiphaga (Turian) Humber, Ben-Ze'ev et Kenneth, *Erynia* 209,
ellisiana (Ben-Ze'ev) Bałazy ex Humber, *Zoophthora* 162, **165**, 175, 314, 318,
ellisiana Ben-Ze'ev, *Erynia* 165,
ellisiana (Ben-Ze'ev) Humber, *Furia* 165,
elongata Geoffr., Notostira 100, 206, 210, 249, 305, 322,
Empoasca fabae (Harris) 171,
elegans Majmone, *Empusa* 117,
Empididae 98, 99, 192, 235, 315,
Empusa 5, 61, 95,
— *acaricida* Petch 134,
— *americana* Thaxter, 162,
— *anticae* Reihardt ex Mitchell 117,
— *apiculata* Thaxter 107, 108,
— *aulicae* Reihardt 114, 117,
— *blissi* 239,
— *caroliniana* Thaxter 131,
— *clisiocampae* Thaxter 165,
— *conglomerata* (Sorokin) Brumpt 119,
— *conica* Nowakowski ex Thaxter 154,
— *culicis* A. Braun 99,
— *dipterigena* Thaxter 185,
— *dysderci* (Viegas) 109,
— *Entomophthora* Fres.ex Thaxter, subg. 147, 154, 156, 158, 159, 162, 169, 185, 186, 219,
— *elegans* Majmone 117,
— *erupta* Dustan 100,
— *forficulae* var. *major* Petch 107, 165, 226, 229,

— *freseniana* Nowakowski 136,
— *fresenii* Nowakowski 136,
— *gracilis* (Thaxter) Batko 156
— *gastropachae* Raciborski 164,
— *lageniformis* Thaxter 136,
— *lampyridarum* Thaxter 131,
— *leanii* Zimmermann 139,
— *megasperma* Brefeld 255,
— *muscae* (Cohn) Fres. 97,
— *papillata* Thaxter, 112,
— *planchoniana* Cornu ex Thaxter 73, 102,
— *radicans* Bref. 207, 209, 222,
— *rhizospora* Thaxter 158,
— *saccharina* Giard ex Lakon 123, 306,
— *sciarae* Olive 157,
— *sepulchlaris* Thaxter 158,
— *tenthredinis* (Fres.), Thaxter 126,
— *thaxteriana* (Petch) Hall et Bell 73,
— *Triplosporium* Thaxter, subg. 133, 136,
— *weberi* Lakon 106,
— *variabilis* Thaxter 159,
Empusaceae 93,
Entomophaga Batko 17, 22, 24, 33, 61, 95, **113**, 114, 125, 134, 288, 304,
— *asiatica* Humber, Soper et Shimazu 117,
— *aulicae* (Reichardt in Bail) Humber 37, 38, 39, 114, 115, 116, **117**, 307,
— *batkoi* (Bałazy) Keller 38, 115, **128**, 306,
— *calopteni* (Bessey) Humber 116, **117**, 307,
— *conglomerata* (Sorokin) Keller 115, **119**, 125, 306,
— *diprionis* Bałazy 38, 116, **126**, 128, 129, 307,
— *domestica* Keller 107, 108,
— *gigantea* (Keller) 109,
— *grylli* (Fres.) Batko 37, 38, 39, 114, **116**, 117, 288, 307,
— *kansana* (Hutchison) Humber 39, 115, **120**, 138, 306,
— *lagriae* Bałazy 115, **121**, 122, 306,
— *Lichia* Weiser et Batko, subg. (nom. nud.) 106,
— *limoniae* Keller 107, 112,
— *macleodii* Humber 116,
— *maimaiga* Humber, Shimazu et Soper 115, **118**, 307,
— *obscura* (Hall et Dunn) Batko 73,
— *papillata* (Thaxter) Keller 112,
— *praxibuli* Humber 117,
— *pyriformis* (Thoizon) Bałazy 114, **119**, 306,
— *saccharina* (Giard) Batko 114, **124**,
— *tabanivora* Anderson et Magnarelli 115, **125**, 306,
— *tenthredinis* (Fres.) Batko 37, 38, 39, 116, **126**, 127, 258, 283, 307,
— *tipulae* (Fres.) Humber 38, 54, 115, 119, **123**, 124, 125, 306,
Entomophthora Fres., 5, 17, 19, 20, 21, 22, 23, 24, 26, 31, 33, 42, **95**, 96, 114, 134, 143, 187, 286, 288, 303, 304,
— *adjarica* Tsintsadze et Vartapetov 142, 143,
— *americana* Thaxter 162,
— *anglica* Petch 193, 198, 201, 209,
— *aphrophorae* Rostrup 239,
— *apiculata* (Thaxter) Gustafsson 107, 288,
— *aphidis* Hoffmann in Fres. 176, 195, 211, 216, 223,
— *aquatica* Anderson et Ringo 152,
— *arrenoctona* Giard 132,
— *atrosperma* Petch *Entomophthora (Tarichium)* 256,
— *auct.* 32, 61, 96,
— *aulice* (Reichardt) Sorokin 117,
— *batkoi* Bałazy 128,
— *blunckii* Lakon ex G. Zimmermann 178,
— *brahminae* Bose et Mehta 178,
— *brevinucleata* Keller et Wilding 39, 97, **98**, 304,
— *bullata* Thaxter in Povah 179,
— *calliphorae* Giard 192, 257, 258,
— *calopteni* Bessey 31, 117,
— *canadensis* MacLeod, Tyrrel et Soper 222,
— *caroliniana* Thaxter ex Keller 131,
— *carpentieri* (Giard) Turian 210,
— *chromaphidis* Burger et Swain 102, 103,
— *cimbicis* Bubak 258,
— *coleopterorum* Petch 236, 237, 259,
— *colorata* Sorokin 116,
— *conglomerata* Sorokin 119,
— *conica* Nowakowski 154,
— *coronata* (Costantin) Kevorkinan 78,
— *creatonotus* Yen 164,
— *crustosa* MacLeod et Tyrrell 164, 165,
— *culicis* (A. Braun) Fres. 39, 97, **99**, 101, 305,
— *curvispora* Nowakowski 154,
— *cyrtoneurae* Giard ex MacLeod et Müller-Kögler *Entomophthora (Tarichium)* 259,
— *delphacis* Hori 183,
— *delpiniana* Cavara 155,
— *destruens* Weiser et Batko 61,
— *dipterigena* Thaxter 185,
— *dissolvens* Vosseler 260,
— *dysderci* (Viegas) MacLeod et Müller-Kögler 19, 109,
— *elateridiphaga* (Turian) Remaud. et Hennebert 193,
— *egressa* MacLeod et Tyrrell 31, 117,
— *erupta* (Dustan) Hall 96, **100**, 304,
— *exitialis* Hall et Dunn 31, 195,

— *forficulae* Giard 165, 226,
— *floridana* Weiser et Muma 142, 143,
— *fresenii* (Nowakowski) Gustafsson 136,
— *fumosa* Speare 139
— *gammae* Weiser ex MacLeod et Müller-Kögler 167,
— *geometralis* Thaxter ex Lakon 229,
— *gigantea* Keller 109,
— *gloespora* Vuill. 173, 191,
— *gracilis* (Thaxter) Remaud. et Hennebert 156,
— *grylli* Fres. 68, 114, 116,
— *helvetica* Keller et Ben-Ze'ev 97, **100**, 305,
— *henrici* Molliard 149, 152,
— *ignobilis* Hall et Dunn 73,
— *inexpectata* Jacz. in Jacz. A. et Jacz. P. ex MacLeod et Müller-Kögler *Entomophthora (Tarichium)* 261,
— *israelenis* Ben-Ze'ev 93, **102**, 305,
— *jaapiana* Bubak *Entomophthora (Tarichium)* 261,
— *kansana* Hutchison 119,
— *lageniformis* (Thaxter) MacLeod et Müller-Kögler 136,
— *lampyridarum* (Thaxter) 131,
— *lauxaniae* Bubak 186,
— *longispora* Bałazy 133,
— *Lophorhiza* Giard, subg. 202, 210, 236,
— *major* (Thaxter) Gustafs. 110,
— *malacosomis* Kevorkian, 165,
— *megasperma* (Cohn) Giard 255,
— *muscae* (Cohn) Fres. 37, 38, 39, 96, **97**, 105, 177, 194, 291, 304,
— *muscae* s.l. 13, 70, 73, 98, 103, 105, 186,
— *muscivora* Schroeter 194, 258,
— *myrmecophaga* Turian et Wuest 188,
— *neopyralidarum* (Ben-Ze'ev) 168,
— *neri* Gustafs. 136,
— *obscura* Hall et Dunn 73,
— *occidentalis* Thaxter 242,
— *ovispora* Nowakowski 151,
— *pallida* Roivainen ex Liro 186,
— *papillata* (Thaxter) Gustafs. 112,
— *parvispora* MacLeod, Tyrrell et Carl 140,
— *phytonomi* Arthur 245, 246,
— *phalangicida* Lagerh. 196,
— *planchoniana* Cornu 37, 73, 97, **102**, 305,
— *pseudococci* (Speare) Tyrrell et MacLeod 82,
— *pyralidarum* Petch 168,
— *pyriformis* Thoizon 119,
— *radicans* (Bref.) Batko 207, 226,
— *rhizospora* Thaxter 158,
— *rimosa* Sorokin 99,
— *saccharina* Giard 123,
— *scatophagae* Giard 97, **103**, 105, 304,
— *schizophorae* Keller et Wilding 97, **103**, 304,
— *sepulchralis* Thaxter 158, .
— *sphaerosperma* Fres. 202, 209, 210, 226, 234, 239, 241, 243, 246, 248, 267, 288,
— *syrphi* Giard 37, 38, 39, 97, 101,
— *tabanivora* Anderson et Magnarelli 125,
— (*Tarichium*) *atrosperma* Petch 256,
— (*Tarichium*) *bereshkoveana* Lavrov et Smirnova ex MacLeod et Müller-Kögler 257,
— (*Tarichium*) *calliphorae* Giard ex MacLeod et Müller-Kögler 117, 257,
— (*Tarichium*) *calopteni* Bessey, MacLeod, Müller-Kögler 117,
— (*Tarichium*) *cimbicis* Bubak ex MacLeod et Müller-Kögler 258,
— (*Tarichium*) *megasperma* Cohn ex MacLeod et Müller-Kögler 165,
— (*Tarichium*) *punctata* Garbowski 269,
— *tenthredinis* Fres. 126, 258,
— *tetranychi* (Weiser) MacLeod et Müller-Kögler 143,
— *thaxteri* Brumpt 125,
— *thaxteriana* (Petch) Hall et Bell 31, 72, 73,
— *thripidum* Samson, Remakers et Oswald 96, **105**, 304,
— *tipulae* Fres. 123, 264,
— *trinucleata* Keller 97, 305,
— *turbinata* Kenneth 134,
— *variabilis* (Thaxter) Lakon 159,
— *vermicola* McCulloch 87,
— *virescens* Li et Humber 169, 170,
— *virulenta* Hall et Dunn 72,
— *weberi* (Lakon) Batko 96, **106**, 304,
— *zabri* Rozsypal 170,
Entomophthoraceae 5, 6, 12, 26, 30, 33, 34, 35, 36, 50, 61, 86, **93**, 94, 108, 145, 284, 285, 286, 291, 292, 302,
Entomophthorales 5, 11, 13, 16, 19, 20, 23, 28, 30, 31, 32, 34, 35, 94, 165, 194, 283,
elongata Geoffroy, Notostira 100, 206, 210, 249, 305, 322,
Eotetranychus sexmaculatus (Riley) 143,
equisetifolia L., Casuarina 73,
Eremaeus oblongus C.L. Koch 253, 325,
erinacea (Ben-Ze'ev et Kenneth) Remaud. et Henneb., *Erynia* 155, 156,
erinacea Ben-Ze'ev et Kenneth, *Zoophthora* 150, **155**, 311,
erupta Dustan, *Empusa* 100,
erupta (Dustan) Hall, *Entomophthora* 96, **100**, 304,
Erynia (Nowakowski) Batko, subg. 13, 20, 22, 23, 24, 26, 28, 29, 36, 143, 147, 148, **149**, 160,

Erynia Nowakowski ss/ Remaud. et Keller 143, 147, 148, 160,
Erynia 160, 211, 311,
— *aquatica* (Anderson et Ringo) Remaud. et Henneb. 152,
— *americana* (Thaxter) 162,
— *anhuiensis* Li 211,
— *aphidis* (Hoffman in Fres.) Humber et Ben-Ze'ev 211,
— *athaliae* Keller 177,
— *anglica* (Petch) Ben-Ze'ev 209,
— *bullata* Thaxter et MacLeod in Humber 179,
— *bullata* (Thaxter in Povah) Remaud. et Henneb. 179,
— *brahminae* (Bose et Mehta) Remaud. et Henneb. 178,
— *conica* (Nowakowski) Remaud. et Henneb. 154,
— *caroliniana* (Thaxter) Remaud. et Henneb. 131,
— *canadensis* (MacLeod, Tyrrell et Soper) Remaud. et Henneb. 222,
— *castrans* (Batko et Weiser) 144,
— *crassitunicata* (Keller) Humber 224,
— *creatonoti* Yen in Humber 164,
— *creatonoti* (Yen) Remaud. et Henneb. 164,
— *crustosa* (MacLeod et Tyrrell) Humber 164,
— *curvispora* (Nowakowski) Nowakowski ex Remaud. et Henneb. 154, 155,
— *dacnusae* Bałazy 183,
— *dipterigena* (Thaxter) Remaud. et Henneb. 185,
— *delphacis* (Hori) Humber 183,
— *delpiniana* (Cavara) Humber 155,
— *elateridiphaga* (Turian) Humber, Ben-Ze'ev et Kenneth 209,
— *ellisiana* Ben-Ze'ev 165,
— *erinacea* (Ben-Ze'ev et Kenneth) Remaud. et Henneb. 155, 156,
— *Erynia* (Nowakowski) Batko, subg. 13, 20, 22, 23, 24, 26, 28, 29, 36, 143, 147, 148, **149**, 151, 153, 154, 155, 156, 157, 158, 170, 178, 287,
— *formicae* Humber et Bałazy 188,
— *forficulae* Giard 226,
— *Furia* Batko, subg. 22, 23, **160**, 167, 168, 313,
— *gammae* (Weiser) Glare et Milner 167,
— *geometralis* (Thaxter) Humber et Ben-Ze'ev 229,
— *gloeospora* (Vuillemin) Remaud. et Henneb. 191,
— *gracilis* (Thaxter) Remaud. et Henneb. 156,
— *ithacensis* Kramer 191,
— *kondoiensis* Milner 195,
— *lanceolata* (Keller) Humber et Ben-Ze'ev 235,
— *minutospora* Keller 168,
— *montana* (Thaxter) Remaud. et Henneb. 157,
— *neoaphidis* Remaud. et Henneb. 175, 216,
— *Neopandora* Ben-Ze'ev et Kenneth, subg. 13, 15, 22, 23, 24, 28, 29, 33, 37, 170, 175, 185, 188, 191, 195, 201,
— *neopyralidarum* (Ben-Ze'ev) Bałazy ex Humber 168,
— *nouryi* Remaud. et Henneb. 195,
— *occidentialis* (Thaxter) Humber et Ben-Ze'ev 242,
— *orientalis* (Ben-Ze'ev et Kenneth) Humber, Ben-Ze'ev et Kenneth 243,
— *ovispora* (Nowakowski) Nowakowski ex Remaud. et Henneb. 29, 54,1 51,
— *phalangicida* (Lagherh.) Remaud. et Henneb. 196,
— *phytonomi* (Arthur) Humber, Ben-Ze'ev et Kenneth 245,
— *phalloides* (Batko) Humber et Ben-Ze'ev 244,
— *pieris* (Li et Humber) Bałazy ex Humber 171,
— *plecopteri* Descals et Webster 157,
— *radicans* (Brefeld) Humber, Ben-Ze'ev et Kenneth 207, 234,
— *rhizospora* (Thaxter) Remaud. et Henneb. 158,
— *sciarae* (Olive) Ben-Ze'ev et Kenneth 169,
— *sepulchralis* (Thaxter) Remaud. et Henneb. 158,
— *suturalis* Ben-Ze'ev 200,
— *variabilis* (Thaxter) Remaud. et Henneb. 159,
— *virescens* (Thaxter) Remaud. et Henneb. 169, 256,
— *vomitoriae* (Rozsypal) Remaud. et Henneb. 201,
— *zabri* Rozsypal ex Ben-Ze'ev et Kenneth 170, 171,
— *Zoophthora* Batko, subg. 20, 21, 22, 23, 24, 25, 28, 37 **201**, 207, 209, 211, 222, 224, 226, 243, 244,
Eryniopsis Humber 21, 36, 43, 94, **130**, 285, 302,
— *caroliniana* (Thaxter) Humber 20, 22, 38, 54, **131**, 132, 302, 308,
— *lampridarum* (Thaxter) Humber 23, 24, 130, **131**, 307,
— *longispora* (Bałazy) Humber 15, 17, 22, 39, 131, **133**, 308,
erythrocephala Meigen, *Calliphora* 201,

Estigmene acrea (Drury) 119,
Euacanthus interruptus L. 251, 262, 323,
Euchelia jacobeae (L.) 123,
euphorbiae (Thomas), Macrosiphum 176,
Euproctis chrysorrhoea (L.) 118,
Eurois occulta L. 252, 262, 324,
eurymitus Drechsler, *Conidiobolus* 63, **68**, 295,
eurypus Drechsler, *Conidiobolus* 81,
Eutetranychus banksi (McGregor) 143,
evansi (Theobald), Microlophium 74, 136, 176, 245,
Eviphis ostrinus (C. L. Koch) 269,
Exidia sp. 75,
exitialis, *Entomophthora* 195,
fabae (Harris), Empoasca 171,
fabae Scopoli, Aphis 79, 102, 136, 176, 195,
falcata Bałazy, *Zoophthora* 203, 213, **225**, 319,
Fannia cunicularis L. 144, 145, 310,
farfara L., Tussilago 226,
fasciata Fallen, Minettia 186,
Fidicina 146,
fidicinae Soper, *Massospora* 146,
firmipilleus Drechsler, *Conidiobolus* 65, 77, **79**, 297,
flammea (Schiff.), Panolis 117,
flaveolus Paykull, Malthinus 193,
flavescens Wick., Sitona 236, 237,
flavipalpana (Herrich-Schäffer), Celypha 224, 322,
flexuosa (L.), Deschampsia 68,
floridana Weiser et Muma, *Entomophthora* 142,
floridana (Weiser et Muma) Remaud. et Keller, *Neozygites* 39, 136, 141, **142**, 143, 309,
floridanum (Weiser et Muma) Weiser, *Triplosporium* 142,
florilega Zett., Hylemya (Delia) 104,
florum (Fabr.), Opomyza 238,
forficela Scop., Harpella 108,
formicae Humber et Bałazy in Humber, *Erynia* 188,
formicae (Humber et Bałazy in Humber), *Pandora* 188,
Forficulidae 162, 166, 314,
Forficula auricularia (L.) 162, 166, 175, 229, 314, 318,
forficulae Giard, *Entomophthora* 165, 226,
forficulae (Giard) Ben-ze'ev, *Erynia* 226,
forficulae (Giard) Ben-Ze'ev, *Zoophthora* 38, 205, 215, **226**, 228, 321,
forficulae var. *major* Petch, *Empusa* 165, 226, 229,
Formica 175, 188, 226, 317,
— polyctena Först. 188,
— rufa L. 188,
Formicidae 188,
fragariae (Walker), Sitobion 176, 242,
frangulae Kaltenbach, Aphis 102, 176,
fresenii (Nowakowski) Batko, *Triplosporium* 136,
fresenii Nowakowski, *Empusa* 136,
fresenii (Nowakowski) Gustafs., *Entomophthora* 136,
fresenii (Nowakowski) Remaud. et Keller, *Neozygites* 37, 134, 135, **136**, 288, 309,
fulva Scop., Rhagonycha 251, 323,
fumimontana Bałazy, *Zoophthora* 161, **166**, 167, 313,
fumosa Speare, *Entomophthora* 139,
fumosa (Speare) Remaud. et Keller, *Neozygites* **139**, 308,
fumosonigrum Bałazy et Wiśniewski, *Tarichium* 253, **260**, 326,
fumosum (Speare) Batko, *Triplosporium* 139,
Furia Batko, subg. 22, 23, **160**, 167, 168, 313,
Furia (Batko) Humber 157,
— *americana* (Thaxter) Humber 162,
— *creatonoti* (Yen in Humber) 164,
— *crustosa* (MacLeod et Tyrrell) Humber 164,
— *ellisiana* (Ben-Ze'ev) Humber 165,
— *ithacensis* (Kramer) Humber 191,
— *montana* (Thaxter) Humber 157, 160,
— *neopyralidarum* (Ben-Ze'ev) Humber 168,
— *pieris* (Li et Humber) Humber 171,
— *sciarae* (Olive) Humber 169,
— *virescens* (Thaxter) Humber 169,
— *vomitoriae* (Rozsypal) Humber 201,
— *zabri* (Rozsypal ex Ben-Ze'ev et Kenneth) Humber 170, 241,
Galerucini 174, 200, 316,
Galuminidae 269, 327,
Gamasida 65, 327,
gamma (L.), Autographa 167, 252, 261, 324,
gammae (Weiser) Bałazy, *Zoophthora* 161, **167**, 313,
gammae Weiser ex MacLeod et Müller, *Entomophthora (Tarichium)* 167,
gammae (Weiser) Glare et Milner, *Erynia* 167,
gammae Weiser, *Tarichium* 167, 168, 325,
gangis (L.), Creatonotus 161, 164, 313,
gastropachae (Raciborski) Bałazy, *Zoophthora* 161, **164**, 314,
gastropachae Raciborski, *Empusa (Entomophthora)* 164,
geometralis (Thaxter) Batko, *Zoophthora* 203, 224, **229**, 318,
geometralis (Thaxter) Gustafs., *Entomophthora* 229,
geometralis Thaxter ex Lakon, *Entomophthora* 229,

geometralis (Thaxter) Humber et Ben-Ze'ev, *Erynia* 229,
Geometridae 118, 229, 318, 319, 322,
giardii Bałazy, *Zoophthora* 38, 205, **230**, 232, 233, 320,
gibbosus (Goeze), Zabrus 170, 252, 262, 325,
gigantea Keller, *Entomophthora* 109,
gigantea (Keller) Humber, *Batkoa* **109**, 305,
gigantea (Keller) Keller, *Entomophaga* 109,
giganteus (Keller) Remaud. et Keller, *Conidiobolus* 109,
gigas (Oliver), Quesada 146,
globuliferus Drechsler, *Conidiobolus* 85,
gloeospora (Vuillemin) Batko, *Zoophthora* **191**, 315,
gloeospora Vuillemin, *Entomophthora* 191,
gloeospora (Vuillemin) Humber, *Pandora* 191,
gloeospora (Vuillemin) Remaud. et Henneb., *Erynia* 191,
gonimodes Drechsler, *Conidiobolus* 79,
gustafssoni Bałazy, *Conidiobolus* 33, 37, 39, 62, **66**, 67, 88, 295,
gracilis (Thaxter) Batko, *Zoophthora* 150, **156**, 311,
gracilis Thaxter, *Empusa* 156,
gracilis (Thaxter) Remaud. et Henneb., *Erynia* 156,
grylli (Fres.) Batko, *Entomophaga* 37, 38, 39, **116**, 288, 307,
grylli Fres., *Entomophthora* 68,
grylli (Fres.) Remaud. et Keller, *Conidiobolus* 116,
Haltica quercetorum Foudr. 108,
haptosporus Drechsler, *Basidiobolus* 52, 54, 293,
Harpella forficela Scop. 108,
Heliaeetus albicilla (L.) 269,
Heliothis armigera Hübner 119,
— zea (Boddie) 119,
helvetica Keller et Ben-Ze'ev, *Entomophthora* 97, **100**, 305,
Hemiptera 34,
henrici Molliard, *Entomophthora* 149, 152,
Heteroptera 37, 100, 107, 109, 162, 168, 189, 190, 235, 239, 249, 305, 314, 317, 322,
heteropteris Bałazy, *Zoophthora* 175, **188**, 190, 206, 317,
heterosporus Drechsler, *Conidiobolus* 83, **84**, 300,
heterosporus Srinivasan et Thrum., *Basidiobolus* 54,
Hibernia defoliaria Cl. 220,
Hirneola 75,
Hirsutella 25,
hirta L., Lagria 115, 121, 122, 123, 306,
Homona magnanima Diakonoff 168,
Homoptera 37, 110, 137, 139, 171, 175, 183, 223, 243, 248, 262,
hondoensis (Ehara), Oligonychus 143,
hortorum Meigen, Cyrtoneura 259,
humberi (Aruta et Carrillo) Bałazy, *Zoophthora* 206, **231**, 321,
humbersi Aruta et Carrillo, *Erynia*, 231,
humicolus Srinivasan et Thirum., *Conidiobolus* 77, **80**, 298,
hyalinum Bałazy, Wiśniewski et Kaczmarek, *Tarichium* 253, **261**, 325,
Hymenoptera 37, 108, 110, 115, 175, 178, 188, 203, 204, 218, 251, 317, 319, 320, 324,
Hylemya 97, 144,
— (Delia) brassicae Bouche 104,
— (Delia) florilega Zetterstedt 104,
— (Delia) platura Meigen 104,
Hypera 252, 269,
Hyphantria cunea Drury 168,
Hyperomyzus lactucae (L.) 196,
hypochaeridis (Hille Ris Lambers), Uroleucon 103, 176,
Hypsibius dujardini (Doyere) 87, 92,
Ichneumonidae 111, 235, 320,
ichneumonis Bałazy, *Zoophthora* 38 204, 227, **231**, 320,
ignobilis Hall et Dunn., *Entomophthora* 73,
imparilis (Butler), Spilosoma 168,
Impatientinum asiaticum (Nevsky) 74, 102, 176, 242,
incongruus Drechsler, *Conidiobolus*, 77, **79**, 299,
indicus Srinivasan et Thirum., *Conidiobolus megalotocus*, var. 80,
inexspectatum Jacz. in Jacz. A. et Jacz. P. ex MacLeod et Müller-Kögler, *Entomophthora* (*Tarichium*) 261,
inexspectatum Jacz., *Tarichium* 252, **261**, 324,
inordinatus Drechsler, *Conidiobolus* 85,
Insecta 79, 314,
insertum (Walk,), Rhopalosiphum 119,
interruptus L., Euacanthus 251, 262, 323,
Ips typographus (L.) 265,
Irbisia solani (Heidemann) 100,
israelensis Ben-Ze'ev, *Entomophthora* 97, 305,
ithacensis (Kramer) Bałazy, *Zoophthora* 39, 160, 173, **191**, 315,
ithacensis Kramer, *Erynia* 191,
ithacensis (Kramer) Humber, *Furia* 191,
jaapiana Bubak, *Entomophthora* (*Tarichium*) 261,
jaapianum (Bubak), *Tarichium* 251, **261**,
jacobeae (L.), Euchelia 123,
jaczewskii Zaprometov ex MacLeod et Müller-Kögler, *Entomophthora* (*Tarichium*) 262,

jaczewskii Zaprometov, *Tarichium* 170, 171, 252, **262**, 325,
Jassidae 180, 244, 317,
Javesella pellucida (Fabr.) 244,
kaemperi Fabr., Platypleura 146,
kansana (Hutchison) Batko, *Entomophaga* 39, 115, **120**, 120, 138, 306,
kansana Hutchison, *Entomophthora* 120,
khandalensis Srinivasan et Thirum., *Conidiobolus* 63, **69**, 296,
kondoi Shinji, *Acyrtosiphon* 174, 195, 317,
kondoienis (Milner) Bałazy, *Zoophthora* 174, **195**, 317,
kondoienis Milner in Milner, Mahon et Brown, *Erynia* 195,
Laboulbeniales 25
Lachnidae 135, 139, 223, 309,
lachnodes Drechsler, *Conidiobolus* 297,
lactucae (L.), Hyperomyzus 196,
laevigatum L., Stenodema 239,
laevinodis Nylander, Myrmica 203, 226, 319,
lageniformis (Thaxter) Batko, *Triplosporium* 136,
lageniformis Thaxter, *Empusa* 136,
lageniformis (Thaxter) MacLeod et Müller-Kögler, *Entomophthora* 136,
lageniformis (Thaxter) Remaud. et Keller, *Neozygites* 135, **136**, 309,
Lagria hirta L. 115, 121, 122, 123, 306,
lagriae, Bałazy, *Entomophaga* 115, **121**, 122, 306,
Lagriidae 115, 123,
Lamia Nowakowski 95, 107,
— *apiculata* (Thaxter) Lakon 107,
— *culicis* (A. Braun) Nowakowski 99,
lamprauges Drechsler, *Conidiobolus* 296,
lampyridarum (Thaxter) Humber, *Eryniopsis* 23, 24, 130, **131**,
lampyridarum Thaxter, *Empusa* 131,
lampyridarum Thaxter ex MacLeod et Müller-Kögler, *Entomophthora* 131,
lanceolata (Keller) Humber et Ben-Ze'ev, *Erynia* 235,
lanceolata Keller, *Zoophthora* 38, 204, 219, 227, **235**, 319,
lanius Gravenhorst, Cratichneumon 234,
lapponicus De Geer, Ectobius 62, 66, 67, 68, 295,
lardaria Fabr., Polietes 155,
latipes Meigen., Simulium 155,
larvivora Bałazy, *Zoophthora* 207, 215, **235**, 259, 322,
lavrovia Gukasjan ex MacLeod et Müller-Kögler, *Entomophthora* (*Tarichium*) 262,
lavrovium Gukasjan, *Tarichium* 252, **262**, 324,
Lasiocampidae 161, 165, 314,
lauxaniae Bubak, *Entomophthora* 186,
Lauxaniidae 152, 172, 186, 314, 324,
lecanii Narasimhan et Thirum., *Derexiomyces* 139,
lecanii (A. Zimmermann) Bałazy, *Neozygites* 135, **139**, 308,
lecanii (A. Zimmermann) Ben-Ze'ev et Kenneth, *Triplosporium* 139,
lecanii A. Zimmermann, *Empusa* 139,
Lecanium viride Green 135, 140, 308,
Ledra aurita L. 108,
Leiobunum blackwalli Meade 130,
— rotundum (Latreille) 130,
Lepidoptera 108, 119, 123, 161, 164, 165, 167, 168, 171, 178, 206, 220, 224, 252, 255, 260, 261, 262, 265, 307, 312, 313, 317, 318, 322, 324, 325,
leptophyei Giard, Polyrhizium 231,
Leptophyes punctatissima (Bosc.) 231, 320,
levispora Soper, *Massospora* 146,
lichenicolus Srinivasan et Thirumalachar, *Conidiobolus* 72,
Lichia Weiser et Batko, *Entomophaga*, subg. 106,
lignosa Müll., Rhagonycha 184, 193, 251, 265, 323,
Limoniidae 124, 125, 306,
limoniae Keller, *Entomophaga* 107, 112,
lineata Erichson, Strongylogaster 126,
lineatus L., Agriotes 210,
lineolatus (Goeze) Adelphocoris 96, 100,
lipai Bałazy, Eilenberg et Papierok, *Zoophthora* 39, 174, 184, **192**, 198, 316,
Lissonota 234,
livida L., Cantharis 192,
lobatus Srinivasan et Thrum. *Conidiobolus* 83, **84**, 300,
Lochmaea suturalis Thomson 200, 201,
Lonchaea vaginalis Fallen 152,
Lonchaeidae 152,
longipennis Fabr., Sapromyza 186,
longispora Bałazy, *Entomophthora* 133,
longispora (Bałazy) Humber, *Eryniopsis* 15, 17, 22, 38, 131, 308,
Lophorhiza Giard, *Entomophthora* subg. 202, 210, 236,
Lucilla 162, 314,
Lucilla caesar L. 162,
luteola (Müller), Pyrrhalta 200,
lugens (Stol.), Nilaparvata 183,
Lyciella
— decipens Loew 186,
— rorida Fallen. 186,
— subfasciata Zetterstadt 186,

Lycoriella mali (Fitch.) 191,
— solani Winn. 185,
Lygus 162, 168, 239, 314,
— communis (L.) var. novascotiensis Knight 100,
— pabulinus (L.) 100,
Lymantria dispar (L.) 119, 307,
Lymantriidae 118, 119,
macleodii Humber, *Entomophaga* 116,
Macrobiotes 91,
Macrobiotophthora 18, 30, 33, 50, 58, **86**, 94, 293, 300,
— *vermicola* (McCulloch) Tucker 32, 86, **87**, 300,
— *vimariensis* Reukauf 86, **87**, 300,
Macrocheles peregrinus Krantz 135, 142, 309,
Macrosiphum euphorbiae (Thomas) 176,
— prenanthidis Börner 74, 176,
— rosae (L.) 103, 176,
macrosporus Srinivasan et Thirum., *Conidiobolus* 77, **79**, 299,
maculatus (Thunberg), Myrmeleotettix 116,
maculipennis Curt., Plutella 178,
Magicicada cassini (Fisher) 146,
— septendecim (L.) 146,
— septendecula Alexander et Moore 146,
— tredecim (Walsh et Riley) 146,
— tredecassini Alexander et Moore 146,
— tredecula Alexander et Moore 146,
magna Humber, *Strongwellsea* 144, **145**, 310,
magnanima Diakonoff, Homona 168,
magnus Drechsler, *Basidiobolus* 55,
maimaiga Humber, Shimazu et Soper, *Entomophaga* 115, **118**, 307,
major Petch, *Empusa forficulae*, var. 107,
major Thaxter, *Empusa apiculata*, var. 110,
major (Thaxter) Humber, *Batkoa* 13, 38, 61, **110**, 305,
major (Thaxter) Gustafs., *Entomophthora* 110,
major (Thaxter) Remaud. et Keller, *Conidiobolus* 107, 110,
Malacosoma 161, 164, 314,
— americanum (Fabr.) 165,
— disstria (Hübn.) 165,
— neustria L. 165,
mali Schmdb., Psylla 248,
mali (Fitsch), Lycoriella 191,
Malthinus flaveolus Paykull 193,
Malthodes 225,
marci L., Bibio 241,
Massospora 19, 21, 22, 31, 93, 94, 96, **145**, 284, 286, 288, 302, 310,
— *carinetae* Soper 146,
— *cicadettae* Soper 146,
— *cicadina* Peck. 145, 146,
— *cleoni* Wize, 259,
— *diceroproctae* Soper 146,
— *diminuta* Soper 146,
— *dorisianae* Soper 146,
— *fidicinae* Soper 146,
— *levispora* Soper 146,
— *ocypetes* Soper 146,
— *pahariae* Soper 146,
— *platypediae* Soper 146,
— *richteri* Bresadola et Staritz 145, 186,
— *spinosa* Ciferri, Machada et Vital 146,
— *staritzi* Bresadola 145,
— *tettigatis* Soper 146,
— *tipulae* Porter 123, 145, 263,
Meconema thalassinum (DeGeer) 231, 232, 320,
megalotocus Drechsler, *Conidiobolus* 64, 65, 77, 79, **81**, 297, 299,
megalotocus var. *indicus* Srinivasan et Thirum., *Conidiobolus* 80, 296,
megasperma Brefeld, *Empusa* 255,
megasperma Cohn ex MacLeod et Müller-Kögler, *Entomophthora* (*Tarichium*) 165,
megasperma (Cohn) Giard, *Entomophthora* 255,
megaspermum Cohn, *Tarichium* 170, 250, 253, **255**, 256, 325,
malanochroa Gmelin, Arge 108,
Melanoplus 116, 307,
— differentialis (Thomas) 117,
Melanostoma 104,
— mellinum L. 152,
— scalare (Fabr.) 101, 105,
Meristacraceae 11, 21, 30, 35, 43, 50, 51, **87**, 94, 284, 285, 289, 292, 300,
Meristacrum 18, 21, 30, **88**, 285, 300, 301,
— *asterospermum* Drechsler 32, **89**, 301,
— *milkoi* (Dudka et Koval) Humber 17, 87, **90**, 301,
— *pendulatum* McCulloch 93,
meristosporus (Drechsler), *Basidiobolus* 52, **55**, 56, 293,
Metopolophium dirhodum (Walker) 176,
microlophii Keller, *Neozygites* 135, 309,
Microlophium carnosum Buckton 137,
— evansi (Theobald) 74, 136, 137, 176, 245,
microsporus Benjamin, *Basidiobolus* 15, 293,
milkoi Dudka et Koval, *Coelomomyces* 90,
milkoi (Dudka et Koval) Couch, Andreeva, Laird et Nolan, *Tabanomyces* 90,
milkoi (Dudka et Koval) Humber, *Meristracum* 17, **90**, 301,
milkoi (Dudka et Koval) Nam et Dubitskii, *Pseudocoelomomyces* 90,
Minettia fasciata Fallen 186,

minima Kramer, Uropoda 255, 263, 327,
minutospora Keller, *Erynia* 168,
minutospora (Keller) Bałazy, *Zoophthora* 162, **168**, 314,
Miridae 100, 162, 168, 206, 239, 249, 305, 314, 320, 322,
miridis Bałazy, *Zoophthora* 38. 39, 204, 228, 235, **238**, 239, 320,
modestum (Hottes), Myzodium 110,
monokaryoticum Bałazy, Wiśniewski et Kaczmarek, *Tarichium* 253, **262**, 326,
montana (Thaxter) Batko, *Zoophthora* 150, **156**, 169, 311,
montana Thaxter, *Empusa* 156,
montana (Thaxter) Humber, *Furia* 157, 160,
montana (Thaxter) Remaud. et Henneb., *Erynia* 157,
mollis Charp., Chorthippus 116,
Mucorales 11, 35,
multivagus Drechsler, *Conidiobolus* 297,
murrayiensis Distant, Cicadetta 146,
Musca 162, 314,
— domestica L. 98, 162, 171,
muscae Cohn, *Empusa* 97,
muscae (Cohn) Fres., *Entomophthora* 37, 38, 39, 96, **97**, 105, 177, 194, 304,
muscae (Cohn) Lebert ex Krenner, *Myiophyton* 97,
muscae s.l., *Entomophthora* 13, 70, 73, 98, 105, 186, 291,
Muscidae 97, 121, 144, 145, 155, 171, 173, 259, 304, 310,
muscivora (Schroeter) Bałazy, *Zoophthora* 39, 173, 180, 181, 192, **194**, 315,
muscivora Schroeter, *Entomophthora* 194, 258,
Mycetophila 191,
Mycetophilidae 108, 185, 191,
Mycodiplosis 99,
mycophagus Srinivasan et Thirum., *Conidiobolus* 81,
mycophilus Srinivasan et Thirum., *Conidiobolus* 76, **81**, 298,
Myiophyton Lebert 95,
— *cohni* Lebert 98,
— *culicis* (A. Braun) v. Arx 99,
— *muscae* (Cohn) Lebert ex Krenner 97,
— *planchonianum* (Cornu) v. Arx 102,
Myrmeleotettix maculatus (Thunberg) 116,
Myrmica laevinodis Nylander 203, 226, 319,
Myrmicidae 319,
myrmecophaga Turian et Wuest, *Entomophthora* 188,
myrmecophaga Turian et Wuest, *Zoophthora* 37, 38, 175, 180, **188**, 317, 288,
mystaceus L., Rhagio 192,
myxophilus Fr., *Basidiobolus* 54,
Myzocallis coryli (Goetze) 137,
Myzodium modestum (Hottes) 110,
Myzus 156,
— persicae Sulz. 176, 196, 203, 211, 318,
nanodes Drechsler, *Conidiobolus* 69,
nasturtii Kaltenbach, Aphis 176,
Nematocera 96, 130, 131, 172, 241, 304, 306, 308, 311, 315, 320,
nematoceris Bałazy, *Zoophthora* 38, 39, 204, 208, 235, **240**, 320,
Nematoda 40, 86, 287,
Nemouridae 150, 158, 312,
neoaphidis (Remaud. et Henneb.) Bałazy, *Zoophthora* 172, 174, **175**, 176, 189, 216, 317,
neoaphidis Remaud. et Henneb., *Erynia* 175, 218,
neoaphidis (Remaud. et Henneb.) Humber, *Pandora* 175,
Neopandora Ben-Ze'ev et Kenneth 13, 15, 22, 23, 24, 28, 29, 33, 37, 149, 160, **171**, 178, 180, 181, 182, 184, 187, 189, 197, 199, 216, 314,
neopyralidarum (Ben-Ze'ev) Bałazy ex Humber, *Zoophthora* 161, **168**, 313,
neopyralidarum Ben-Ze'ev, *Erynia* 168,
neopyralidarum Petch., *Entomophthora* 168,
neopyralidarum (Ben-Ze'ev) Humber, *Furia* 168,
Neozygitaceae Humber 12, 35, 50, 94, 134, 285,
Neozygites Witlaczil 12, 22, 23, 24, 26, 31, 95, **133**, 134, 140, 141, 283, 285, 288, 303, 308,
— *acaridis* (Petch) Milner 135, **142**, 309,
— *adjarica* (Tsintsadze et Vartapetov) Remaud. et Keller 142,
— *aphidis* Witlaczil 136,
— *cucumeriformis* Bałazy et Miętkiewski 135, **140**, 141, 309,
— *floridana* (Weiser et Muma) Remaud. et Keller 39, 136, **142**, 143, 309,
— *fumosa* (Speare) Remaud. et Keller 135, **139**, 308,
— *fresenii* (Nowakowski) Remaud. et Keller 37, 134, 135, **136**, 288, 309,
— *lageniformis* (Thaxter) Remaud. et Keller 135, **136**, 309,
— *lecanii* (Zimmermann) Bałazy 135, **139**, 308,
— *microlophii* Keller 135, **137**, 138, 309,
— *parvispora* (MacLeod, Tyrrell et Carl) Remaud. et Keller 135, **140**, 142, 308,
— *tetranychi* (Weiser) Remaud. et Keller 136, **143**, 309,

— *turbinata* (Kenneth) Remaud. et Keller 22, 135, **137**, 309,
Nephrotoma 132,
netrii Couch, *Ancylistes* **59**, 294,
Neuroptera 37,
Neuropteroidea 106,
neustria L., Malacosoma 165,
Netrium digitus (Ehrenb.) Itzigsohn et Rothe 59, 294,
nigrovittatus Zett., Tabanus 125,
Nilaparvata lugens (Stol.) 183,
Noctuidae 118, 161, 167, 252, 253, 255, 257, 260, 261, 262, 265, 313, 324, 325,
nodosus Srinivasan et Thirum., *Conidiobolus* 71,
novascotiensis Knight, Lygus communis, var. 100,
Notostira elongata Geoffroy 100, 206, 210, 249, 305, 322,
nouryi (Remaud. et Henneb.) Ben-Ze'ev et Kenneth, *Zoophthora* 39, 174, **195**, 196, 216, 317,
nouryi Remaud. et Henneb., *Erynia* 195,
nouryi (Remaud. et Henneb.) Humber, *Pandora* 195,
oblongus C. L. Koch, Eremaeus 253, 325,
obscura (Hall et Dunn) Batko, *Entomophaga* 73,
obscura Hall et Dunn, *Entomophthora* 73,
obscurus (Hall et Dunn) Remaud. et Hennb., *Conidiobolus* 31, 32, 37, 72, **73**, 137, 138, 297,
obscurus L., Agriotes 210,
obtusa Bałazy, *Zoophthora* 205, 227, **241**, 320,
obtusoangulatum Bałazy et Wiśniewski, *Tarichium* 255, **263**, 327,
occidentalis (Thaxter) Batko, *Zoophthora* 206, 212, **242**, 322,
occidentalis Thaxter, *Empusa* subg. 242, 243, 245,
occidentalis (Thaxter) Humber et Ben-Ze'ev, *Erynia* 242,
occulta L., Eurois 252, 262, 324,
ocypetes Soper, *Massospora* 146,
Oecophoridae 108,
Okanagana rimosa (Say) 146,
— sperata Van Duzee 146,
Oligolophus triedens C.L. Koch 130,
Oligonychus hondoensis (Ehara) 143,
ophiopsis L., Raphidia 106, 304,
oplitidis Bałazy et Wiśniewski, *Tarichium* 254, **263**, 326,
Oplitis alophora (Berlese) 254, 263, 326,
Opiliones 34, 40, 288, 306, 314,
opomyzae Bałazy, *Zoophthora* 38, 39, 204, 208, **237**, 319,
Opomyza florum (Fabr.) 238,
Opomyzidae 319,
Orgyia pseudotsugata McDunnough 119,
Oribatida 326,
orientalis (Ben-Ze'ev et Kenneth) Humber, Ben-Ze'ev et Kenneth, *Erynia* 243,
orientalis Ben-Ze'ev et Kenneth, *Zoophthora* 205, **243**, 321,
Orthoptera 37, 115, 116, 307, 320,
Orthorrhapha 98,
osmodes Drechsler, *Conidiobolus* 32, 39, 246, 269, 296,
ostrinus (C.L. Koch), Eviphis 269,
ovalis Koch, Trichouropoda 263,
ovatus (C.L. Koch), Adoristes 92,
ovispora (Nowakowski) Batko, *Zoophthora* 29, 39, 54, 55, 121, 138, 149, 150, **151**, 152, 159, 312,
ovispora Nowakowski, *Entomophthora* 151,
ovispora (Nowakowski) Nowakowski ex Remaud. et Henneb., *Erynia* 151,
ovispora (Nowakowski) Remaud. et Henneb. ex Humber, *Erynia* 151,
pabulinus (L.), Lygus 100,
padi (L.), Rhopalosiphum 119,
Paharia cassyapae (Distant) 146,
pahariae Soper, *Massospora* 146,
paludosa Meigen, Tipula 110,
pallida Roivainen ex Liro, *Entomophthora* (*Tarichium*) 186,
pallidus Herrich-Schäffer, Dicyphus 239,
Pandora Batko, subg. 171,
Pandora Humber 180, 191, 216,
— *blunckii* (Lakon ex G. Zimmermann) Humber 178,
— *brahminae* (Bose et Mehta) Humber 179,
— *bullata* (Thaxter et MacLeod) Humber 179,
— *dacnusae* (Bałazy) Humber 183,
— *delphacis* (Hori) Humber 183,
— *dipterigena* (Thaxter) Humber 185,
— *echinospora* (Taxter) Humber 185,
— *formicae* (Humber et Bałazy in Humber) Humber 188,
— *gammae* (Weiser) Humber 168,
— *gloeospora* (Vuillemin) Humber 191,
— *kondoiensis* (Milner) Humber 195,
— *neoaphidis* (Remaud. et Henneb.) Humber 175,
— *nouryi* (Remaud. et Henneb.) Humber 195,
— *phalangicida* (Lagerh.) Humber 196,
— *suturalis* (Ben-Ze'ev) Humber 200,
Panolis flammea (Schiff.) 117,
Panonychus citri Risso 143,
papillata (Thaxter), *Empusa* 112,

papillata (Thaxter) Gustafs., *Entomophthora* 112,
papillata (Thaxter) Humber, *Batkoa* **112**, 305,
papillata (Thaxter) Keller, *Entomophaga* 112,
papillatus (Thaxter) Remaud. et Keller, *Conidiobolus* 112,
Parasitiformes 268, 326,
parvispora MacLeod, Tyrrell et Carl, *Entomophthora* 140,
parvispora (MacLeod, Tyrrell et Carl) Remaud. et Keller, *Neozygites* **140**, 142, 308,
parvus Drechsler, *Conidiobolus* 70,
paulus Drechsler, *Conidiobolus* 70, 296,
pedicellata Pohlad et Bernard, *Ballocephala* 301,
pellucida (Fabr.), Javesella 244,
Pemphigus 39,
— bursarius L. 174, 195, 317,
— phenax Börner, 195,
pendulatum McCulloch, *Meristracum* 93,
pendulatus (McCulloch) Tucker, *Zygnemomyces* 92, **93**, 302,
pennsylvanicus De Geer, Chauliognathus 130, 131, 307,
peregrinus Kratz., Macrocheles 135, 142, 309,
Pergamasus 75, 253, 254, 255, 256, 260, 264, 266, 267, 268, 269, 325, 326, 327,
— brevicornis (Berlese) 254, 257, 327,
— crassipes (L.) 142,
— septentrionalis (Oud.) 196, 197,
persicae (Cholodk.), Pterochlorides 139,
persicae (Sulz.), Myzus 176, 196, 203, 211, 318,
petchii Ben-Ze'ev et Kenneth, *Zoophthora* 39, 205, 214, **243**, 321,
pfeifferi Beck ex Tucker, *Ancylistes* 58, **60**, 294,
Phaenicia sericata (Meigen) 179,
phalangicida (Lagerh.) Batko, *Zoophthora* 172, **196**, 197, 314,
phalangicida Lagerh., *Empusa* 194,
phalangicida (Lagerh.) Humber, *Pandora* 196,
phalangicida (Lagerh.) Remaud. et Henneb., *Erynia* 196,
phalaridis Kieff., Sitodiplosis 99,
phalloides (Batko) Humber et Ben-Ze'ev, *Erynia* 244,
phalloides Batko, *Zoophthora* 206, 243, **244**, 245, 322,
Phenacoccus 135, 139, 308,
— citri (Risso) 139,
Philaenus spumarius (L.) 244,
philonthi Bałazy, *Zoophthora* 39, 174, **197**, 199, 316,
Philonthus 198, 199, 316,
Phormia regina (Meigen) 179,
Phrygaena 158,
phyllobii Bałazy, *Zoophthora* 38, 174, 181, **199**, 316,
Phyllobius 174, 200, 237, 316,
phytonomi (Arthur) Batko, *Zoophthora* 37, 39, 206, 221, 228, 232, **245**, 269, 322,
phytonomi Arthur, *Entomophthora* 245, 246,
phytonomi (Arthur) Humber, Ben-Ze'ev et Kenneth, *Erynia* 245,
Phytonomus 32, 71, 206, 246, 252, 269, 322, 325,
— punctatus Fabr. 246,
— variabilis Herbst. 246,
Pieridae 171, 314,
Pieris brassicae L. 205, 208, 209, 320,
— rapae L. 161, 171, 209, 314, 320,
pieris (Li et Humber) Bałazy ex Humber, *Zoophthora* 161, **171**, 314,
pieris Li et Humber, *Erynia* 171,
pieris (Li et Humber) Humber, *Furia* 171,
Pilobolaceae 35,
pinguis Marcus, Diphascon 92,
piniradiatae (Davidson), Schizolachnus 205, 223, 321,
pipiens L., Culex 66, 152,
pisi (Winn.), Contarinia 99,
pisum (Harris), Ancyrtosiphon 74, 79, 102,
Plagiognathus 100,
planchoniana (Cornu) Thaxter, *Empusa* 73, 102,
planchoniana Cornu, *Entomophthora* 97, 305,
planchonianus (Cornu) v. Arx, *Myiophyton* 102,
platanoidis (Schrank), Drepanosiphum 102, 176,
platura Meig., Hylemyia (Delia) 104,
platypterus Fabr., Sciopus 108,
Platypalpus 192,
Platypedia puntami Soper 146,
platypediae Soper, *Massospora* 146,
Platycheirus 104,
— clypeatus Meigen 105,
Platypleura kaempferi Fabr. 146,
platypterus Fabr., Sciopus 108,
Plecoptera 150, 158, 312,
plecopteri Descals et Webster, *Erynia* 157,
plecopteri (Descals et Webster) Bałazy, *Zoophthora* 150, **157**, 312,
Plutella maculipennis Curt. 178,
— xylostella (L.) 178,
Plutellidae 178,
podagraria L., Aegopodium 177,
Podura 155,
Polietes lardaria Fabr. 155,

Pollenia rudis Fabr. 97, 98, 104,
poloniaemajoris Bałazy, *Zoophthora* 174, **180**, 181, 182, 317,
polyctena Först., Formica 188,
Polyrhizium leptophyei Giard 231,
polyspermus Drechsler, *Conidiobolus* 81,
polytocus Drechsler, *Conidiobolus* 77, **82**, 299,
populifolia Marsch., Betula 137,
porteri (Soper) Bałazy, *Tarichium* 145, 252, **263**, 325,
porteri Soper, *Entomophthora* 263,
praeusta Fallen, Tricholeuxania 108,
praxibuli Humber, Milner et Soper, *Entomophaga* 117,
prenanthidis (Börner), Macrospihum 74, 176,
pseudapiculatus Keller, *Conidiobolus* 35,
pseudococci Speare, *Entomophthora* 82,
pseudococci (Speare) Tyrrell et MacLeod, *Conidiobolus* 33, **82**, 298,
Pseudococcidae 139,
Pseudococcus calceolariae Maskell 83,
Pseudococcus citri 298,
Pseudocoelomomyces milkoi (Dudka et Koval) Nam et Dubitskii 90,
pseudoplatanus L., Acer 180,
pseudotsugata McDunnough, Orgyia, 119,
Psychodidae 108, 152, 153, 159,
Psylla mali Schmdb. 248,
psyllae Bałazy, *Zoophthora* 204, 214, 235, **247**, 320,
Psyllidae 248,
Psyllodea 108,
Pterochlorides persicae (Cholodkovskii) 139,
Pteromalidae 227, 235,
Ptilodactyla serricollis (Say) 110,
puer Walker, Cicadetta 146,
pumilus Drechsler, *Conidiobolus* 84, **85**, 300,
punctata Garbowski, *Entomophthora (Tarichium)* 269,
punctatissima (Bosc.), Leptophyes 231, 320,
punctatum-complex, *Tarichium* 252, **269**, 325,
punctatus Fabr. Phytonomus 246,
punctiventris (Germar), Bothynoderes 259, 324,
punctiventris (Germar), Cleonus 251,
puntami, Platypedia 146,
pusillum Bałazy et Wiśniewski, *Tarichium* 253, **264**, 325,
pustulata Weiser ex MacLeod et Müller-Kögler, *Entomophthora* (*Tarichium*) 264,
pustulatum Weiser, *Tarichium* 253, **264**, 325,
Pyralidae 118,
pyralidarum Petch, *Entomophthora* 168,
pyramidea L., Amphipyra 170,
pyriformis (Thoizon) Bałazy, *Entomophaga* 114, **119**, 306,
pyriformis Thoizon, *Entomophthora* 119,
Pyrrhalta luteola (Müller) 200,
Pyrrhocoridae 107, 109, 305,
quercetorum Foudr., Haltica 108,
quercus Fabr., Typhlocyba 108,
Quesada gigas (Oliver) 146,
radicans (Brefeld) Batko, *Zoophthora* 39, 147, 205, **207**, 218, 222, 234, 241, 248, 320,
radicans Brefeld, *Empusa* 207, 209, 222,
radicans Brefeld, *Entomophthora* 207, 226, 239,
radicans (Brefeld) Humber, Ben-Ze'ev et Kenneth in Humber et Ben-Ze'ev, *Erynia* 207, 234,
ranarum Eidam, *Basidiobolus* 6, 14, 16, 17, **52**, 53, 55, 57, 263, 293,
rapa L., Brassica 105, 209, 320,
rapae (L.), Pieris 171,
Raphidia ophiopsis L. 106, 304,
Raphidioptera 37, 96,
Raphidiidae 106,
regina (Migen), Phormia 179,
relictus Meigen, Chrysops 90,
reuteri (Uzel.), Drepanothrips 135, 141, 142, 309,
Rhagidiasporidium svalbardense Thor 268,
Rhagio conspicuus Meigen 108, 192,
— mystaceus L. 192,
— scolopaceus L. 192,
Rhagionidae 153, 159, 192, 315,
Rhagonycha fulva Scop. 251, 323,
— lignosa Müller 184, 193, 251, 265,
rhagonycharum Bałazy, *Tarichium* 38, 251, **265**, 323,
rhizospora (Thaxter) Batko, *Zoophthora* 151, **158**, 312,
rhizospora Thaxter, *Empusa* 158,
rhizospora Thaxter ex Lakon, *Entomophthora* 158,
rhizospora (Thaxter) Remaud. et Hennebert, *Erynia* 158,
Rhopalosiphum insertum (Walk.) 119,
— padi (L.) 119,
Rhynchota 174, 316,
rhysosporus Drechsler, *Conidiobolus* 84, **85**, 300,
ribis (L.), Cryptomyzus 102, 176,
richteri Bres. et Staritz, *Massospora* 145, 186,
richteri (Bres. et Staritz) Bubak, *Tarichium* 145,
rimosa (Say), Okanagana 146,
rimosa Sorokin, *Entomophthora* 99,
rorida Fallen., Lyciella 186,
rosae L., Athalia 175, 178, 317,
rosae (L.), Macrospihum 103, 176,

rotundum (Latreille), Leiobunum 130,
rubi (Kaltenbach), Amphorophora 176,
rudis Fabr., Pollenia 97, 98, 104,
rufa L., Formica 188,
ruficornis Geoffroy, Trigonotylus 168,
rufiventris, Anomala 174, 179, 316,
rugosus Drechsler, *Conidiobolus* 84,
rustica Fallen, Cantharis 193,
saccharina (Giard) Batko, *Entomophaga* 114, **123**, 306,
saccharina Giard, *Entomophthora* 123,
saccharina Giard ex Lakon, *Empusa* 123,
saliganus Gmelin, Tuberolachnus 139,
sanguinea L., Cornus 216,
Sapromyza longipennis Fabr. 186,
Sarcophaga aldrichi Parker 179,
Sarcophagidae 54, 121, 152, 179,
satellitia (L.), Cerastis 252, 260, 324,
scalare (Faber), Melanostoma 101,
Scarabaeidae 174, 179, 316,
Scatophaga stercoraria L. 103,
scatophagae Giard, *Entomophthora* 97, **103**, 105, 304,
Scatophagidae 97, 103, 304,
Scatopsidae 108,
Schizolachnus piniradiatae (Davidson) 205, 223, 321,
schizophorae Keller et Wiling in Keller, *Entomophthora* 97, **103**,
Sciara 169,
sciarae (Olive) Bałazy ex Humber, *Zoophthora* 162, **169**, 314,
sciarae (Olive) Ben-Ze'ev et Kenneth, *Erynia* 169,
sciarae Olive, *Empusa* 157, 169,
sciarae (Olive) Humber, *Furia* 169,
Sciaridae 81, 106, 108, 169, 185, 191, 241, 305, 314,
Sciopus platypterus Fabr. 108,
Scolobatini 234,
scolopaceus L., Rhagio 192,
segetum (Denis et Schiff.), Agrotis 167, 255, 256,
Selandria 126,
semilata (Walker), Dorisiana 146,
Septobasidium apiculatum Couch 78,
septentrionalis (Oud.), Pergamasus 197,
septendecim (L.), Magicicada 146,
septendecula Alexander et Moore, Magicicada 146,
sepulchralis (Thaxter) Batko, *Zoophthora* 39, 151, **158**, 312,
sepulchralis Thaxter, *Empusa* 158,
sepulchralis Thaxter ex Lakon, *Entomophthora* 158,
sericata (Meigen), Phaenicia 179,
serricollis (Say), Ptilodactyla 110,
sexmaculatus (Riley), Eotetranychus 143,
silesianum Bałazy et Wiśniewski, *Tarichium* 254, **265**, 327,
silvatica L., Stachys 180,
simile Hartig, Diprion 307,
similis v. d. Goot, Capitophorus 74, 102, 176, 242, 243,
Simuliidae 99, 155,
Simulium latipes Meigen 155,
Sitobion avenae (Fabr.) 102, 119, 176,
— fragariae (Walker) 176, 242,
Sitodiplosis phalaridis Kieff. 99,
Sitona flavescens Wick 236, 237,
sloviniense Bałazy et Wiśniewski, *Tarichium* 254, **266**, 327,
Solanaceae 72,
solani (Heidemann), Irbisia 100,
solani (Kaltenbach), Aulacorthum 102, 176,
solani Winn, Lycoriella 185,
Solidago 137,
sperata Van Duzee, Okanagana 146,
sphaericum Bałazy et Wiśniewski, *Tarichium* 253, 254, **266**, 326,
sphaerosperma Drechsler, *Ballocephala* 17, 301,
sphaerosperma Fres., *Entomophthora* 202, 209, 210, 226, 234, 239, 241, 243, 246, 248, 267, 288,
sphaerospermum Cohn, *Tarichium* 251, **266**, 267, 323,
Spilosoma imparilis (Butler) 168,
spumarius (L.), Philaenus 244,
sputator L., Agriotes 210, 236,
Stachys silvatica L. 180,
Staphylinidae 249, 316, 319,
staritzii Bresadola, *Massospora* 145,
Stenodema laevigatum L. 239,
— virens L. 239,
stercoraria L., Scatophaga 103,
Stratiomyidae 201,
Streptomyces 52, 54, 293,
stromoideus Srinivasan et Thirum., *Conidiobolus* 296,
Strongwellsea Batko et Weiser 11, 12, 31, 35, 95, **143**, 284, 288, 303, 309,
— *castrans* Batko et Weiser **144**, 309,
— *magna* Humber 144, **145**, 310,
Strongylogaster lineata Erichson 126,
subfasciata Zetterstatd, Lyciella 186,
subglobosum Bałazy et Wiśniewski, *Tarichium* 254, **267**, 327,
subpunctulatum Bałazy, *Tarichium* 251, **267**, 323,

suturalis (Ben-Ze'ev) Bałazy, *Zoophthora* 174, 180, **200**, 316,
suturalis Ben-Ze'ev, *Erynia* 200,
suturalis (Ben-Ze'ev) Humber, *Pandora* 200,
suturalis Thomson, Lochmaea 200, 201,
Symphoromyia 192,
Syrphidae 97, 98, 104, 152, 159, 201, 304,
syrphi Giard, *Entomophthora* 37, 38, 39, 97, 101, **104**, 304,
Syrphus 104, 105,
— tricinctus Fallen 105,
svalbardense-complex, *Tarichium* 253, **267**, 326,
svalbardense (Thor), Bałazy et Wiśniewski, *Tarichium* 267,
svarbardense Thor, *Rhagidiasporidium* 268,
szczecinensis Wiśniewski et Hirschmann, Trichouropoda 253, 263, 326,
tabaci Lindemann, Thrips 140, 304,
Tabanidae 88, 90, 125, 306,
tabanivora Anderson et Magnarelli, *Entomophthora* 125,
tabanivora (Anderson et Magnarelli)) Humber, *Entomophaga* 115, **125**, 306,
Tabanomyces milkoi (Dudka et Koval) Couch, Andreeva, Laird et Nolan 90,
Tabanus autumnalis L. 90,
— nigrovittatus Zett. 125,
tachypori Bałazy, *Zoophthora* 38, 203, 212, **248**, 319,
Tachyporus 203, 249, 319,
Tachinidae 121,
Tardigrada 41, 86, 287, 300,
Tarichium Cohn 16, 18, 39, 50, **250**, 292, 323,
— *acariocolum* Bałazy et Wiśniewski 255, **256**, 327,
— *aphidis* (Hoffman in Fres.), Cohn 211, 251,
— *atrospermum* (Petch) Bałazy 252, **256**, 324,
— *azygosporicum* Bałazy, Wiśniewski et Kaczmarek 254, **257**, 327,
— *bereshkoveanum* Lavrov et Smirnova 252, **257**, 325,
— *calliphorae* (Giard) Bałazy 37, 251, **257**, 323,
— *cimbicis* (Bubak) Lakon 251, **258**, 324,
— *cleoni* (Wize) Lakon 251, **259**, 324,
— *coleopteroum* (Petch) Bałazy 236, 252, **259**, 324,
— *cyrtoneurae* (Giard) Bałazy 251, **259**, 323,
— *dissolvens* (Vosseler) Lakon 252, **260**, 324,
— *distinctum* Bałazy, Wiśniewski et Kaczmarek 254, **260**, 326,
— *fumosonigrum* Bałazy et Wiśniewski 253, **260**, 326,
— *gammae* Weiser 167, 168, 325,
— *hyalinum* Bałazy, Wiśniewski et Kaczmarek 253, **261**, 325,
— *hylemyiae* Lakon 144,
— *inexspetatum* Jaczevskii 252, **261**, 324,
— *jaapianum* (Bubak) Bałazy 251, **261**, 323,
— *jaczewskii* Zaprometov 170, 171, 252, **262**, 325,
— *lavrovium* Gukasjan 252, **262**, 324,
— *megaspermum* Cohn 165, 179, 250, 253, **255**, 256, 325,
— *monokaryoticum* Bałazy 253, **262**, 326,
— *obtusoangulatum* Bałazy et Wiśniewski 255, **263**, 327,
— *oplitidis* Bałazy et Wiśniewski 254, **263**, 326,
— *porteri* (Soper) Bałazy 123, 145, 252, **263**, 325,
— *punctatum*-complex 252, **269**, 325,
— *pusillum* Bałazy et Wiśniewski 253, **264**, 325,
— *pustulatum* Weiser 253, **264**, 325,
— *rhagonycharum* Bałazy 38, 251, **265**, 323,
— *richteri* (Bresadola et Staritz) Bubak 145,
— *silesianum* Bałazy et Wiśniewski 254, **265**, 327,
— *sloviniense* Bałazy et Wiśniewski 254, **266**, 327,
— *sphaericum* Bałazy et Wiśniewski 253, **266**, 326,
— *sphaerospermum*-complex 251, 255, **266**, 267, 323,
— *subglobosum* Bałazy et Wiśniewski 254, **267**, 327,
— *subpunctulatum* Bałazy 251, **267**, 323,
— *svalbardense*-complex 253, **267**, 326,
— *svalbardense* (Thor), Bałazy et Wiśniewski 268,
— *tatricum* Bałazy et Wiśniewski 253, **268**, 326,
— *tenuiparietatum* Bałazy et Wiśniewski 253, **268**, 326,
— *tenuisculpturatum* Bałazy et Wiśniewski 255, **268**, 327,
— *uropodinis* Bałazy et Wiśniewski 254, **269**, 326,
— *verruculosum* Bałazy, Wiśniewski et Kaczmarek **269**, 327,
tatricum Bałazy et Wiśniewski, *Tarichium* 253, **268**, 326,
Tectocepheus velatus (Michael) 261,
tenebrioides Goeze, Zabrus 161, 170, 173, 313, 315,
Tenthredinidae 143, 175, 178, 288, 307, 317,
tenthredinis (Fres.) Batko, *Entomophaga* 37, 38, 39, 116, **126**, 127, 283, 307,

tenthredinis Fres. *Entomophthora* 126, 128,
tenthredinis (Fresenius) Thaxter, *Empusa* 126,
tenuiparietatum Bałazy et Wiśniewski, *Tarichium* 253, **268**, 326,
tenuisculpturatum Bałazy et Wiśniewski, *Tarichium* 255, **268**, 327,
tetranychi (Weiser) MacLeod et Müller-Kögler, *Entomophthora* 143,
tetranychi (Weiser) Remaud. et Keller, *Neozygites* 136, **143**, 309,
tetranychi Weiser, *Triplosporium* 143,
Tetranychidae 135, 309,
Tetranychus althae Hanstein 143,
— urticae Koch 141, 143, 202,
Tettigates 146,
tettigatis Soper, *Massospora* 146,
Tettigonidae 320,
terrestris Srinivasan et Thirum., *Conidiobolus* 71,
thallassinum (DeGeer), Meconema 231, 232, 320,
thaxteri Brumpt, *Entomophthora* 125,
thaxteriana (Petch) Batko, *Entomophaga* 31, 72, 73,
thaxteriana Petch, *Empusa* 73,
thaxteriana (Petch) Hall et Bell, *Entomophthora* 72,
Thaxterosporium Ben-Ze'ev 133, 134,
— *turbinatum* (Kenneth) Kenneth et Ben-Ze'ev 137,
Therioaphis trifolii (Monell) 196,
Thermobia domestica (Packard) 79,
thoracicus (Heine), Atylotys 125,
Thripidae 105, 140, 142, 231, 304,
thripidum Samson, Ramakers et Oswald, *Entomophthora* 96, **105**, 304,
Thrips 135, 140, 308,
— tabaci Lindemann 96, 105, 140, 304,
thromboides Drechsler, *Conidiobolus* 14, 33, 296,
Thysanoptera 105, 135, 288, 308,
Tipula 110, 131,
— paludosa Meigen 110, 132,
— triplex colei Alexander 264,
tipulae Fres., *Entomophthora* 123,
tipulae (Fres.) Humber, *Entomophaga* 39, 54, 115, 119, **123**, 124, 125, 264, 305,
tipulae (Porter) MacLeod et Müller-Kögler, *Entomophthora* (*Tarichium*) 123, 263,
tipulae Porter, *Massospora* 123, 145, 263,
Tipulidae 110, 119, 125, 131, 132, 152, 153, 159, 185, 252, 263, 305, 308, 312, 321, 325,
Tortricidae 118, 224, 322,
Trachyuropoda coccinea (Michael) 253, 254, 266, 269, 326,
tredecassini Alexander et Moore, Magicicada 146,
tredecim (Walsh et Riley), Magicicada 146,
tredecula Alexander et Moore, Magicicada 146,
Tremellales 75,
Tricholauxania praeusta Fallen 108,
Trichoptera 151, 312,
Trichouropoda ovalis Koch 263,
Trichouropoda szczecinensis Hirschmann et Wiśniewski 253, 263, 326,
tricinctus Fallen, Syrphus 105,
triedens C. L. Koch, Oligolophus 130,
trifolii (Monell), Therioaphis 196,
Trigonotylus ruficornis Geoffroy 168,
trinucleata Keller, *Entomophthora* 97, **105**, 305,
Trioza urticae L. 248, 320,
Triplosporium (Thaxter) Batko 133,
— *floridanum* (Weiser et Muma) Weiser 142,
— *fresenii* (Nowakowski) Batko 136,
— *fumosum* (Speare) Batko 139,
— *lageniformis* (Thaxter) Batko 136,
— *lecanii* (Zimmermann) Ben-Ze'ev et Kenneth 139,
— *tetranychi* Weiser 143,
Tuberolachnus salignus Gmelin 139,
turbinata Kenneth, *Entomophthora* 134, 137,
turbinata (Kenneth) Remaud. et Keller, *Neozygites* 22, 135, **137**, 309,
turbinatum (Kenneth) Kenneth et Ben-Ze'ev in Ben-Ze'ev, Kenneth et Uziel, *Thaxterosporium* 137,
tussilaginis (Walker), Uroleucon 74, 103, 176,
Tussilago farfara L. 226,
Typhlocyba quercus Fabr. 108,
typographus L., Ips 265,
Tyroglyphidae 79,
umbrella Börner, Aphis 174, 317,
Uroleucon cirsii (L.) 74, 103, 176,
— hypochaeridis (Hille Ris Lambers) 103, 176,
— tussilaginis (Walker) 74, 103, 176,
Uropoda minima Kramer 255, 263, 327,
uropodinis Bałazy et Wiśniewski, *Tarichium* 254, **267**, 326,
urticae Koch, Tetranychus 141, 143, 202,
urticae L., Trioza 248, 320,
Ustilaginales 34,
ustulatus Schall., Agriotes 210,
utriculosus Brefeld, *Conidiobolus* 60, **74**, 296,
vaginalis Fallen, Lonchaea 152,
variabilis Herbst, Phytonomus 246,
variabilis (Thaxter) Batko, *Zoophthora* 38, 151, 153, **159**, 312,

variabilis Thaxter, *Empusa* 159,
variabilis Thaxter ex Lakon, *Entomophthora* 159,
variabilis (Thaxter) Remaud. et Hennebert, *Erynia* 159,
Veigaia 254, 265, 268, 327,
velatus (Michael), Tectocepheus 261,
vermicola McCulloch, *Entomophthora* 87,
vermicola (McCulloch) Tucker, *Macrobiotophthora* 32, 86, **87**, 300,
verrucospora Richardson, *Ballocephala* **91**, 301,
verruculosum Bałazy, Wiśniewski et Kaczmarek, *Tarichium* 254, **269**, 327,
Vicia 142,
villosus Martin, *Conidiobolus* 78,
vimariensis Reukauf, *Macrobiotophthora* 86, **87**,
virens L., Stenodema 239,
virescens (Thaxter) Batko, *Zoophthora* 160, 161, **169**, 170, 256, 313,
virescens (Thaxter) Humber, *Furia* 169,
virescens Thaxter ex Lakon, *Entomophthora* 169, 170,
virescens (Thaxter) Remaud. et Henneb., *Erynia* 169, 256,
viride Green, Lecanium 135, 140, 308,
viridicosta Davis, Diceroprocta 146,
viridis Keller, *Zoophthora* 206, 210, **249**, 250, 322,
virulenta (Hall et Dunn) Batko, *Culicicola* 72,
virulenta Hall et Dunn, *Entomophthora* 72,
vomitoria L., Calliphora 162, 194, 201, 258,
vomitoriae (Rozsypal) Humber, *Furia* 201,
vomitoriae (Rozsypal) Remaud. et Hennebert, *Erynia* 201,
vomitoriae Rozsypal, *Zoophthora* 13, 38, 160, 173, 181, 194, **201**, 315,
weberi (Lakon) Batko, *Entomophthora* **106**, 304,
weberi Lakon, *Empusa* 106,
xylostella (L.), Plutella 178,
zabri Humber, *Erynia* 170, 171,
zabri (Rozsypal ex Ben-Ze'ev et Kenneth) Bałazy ex Humber, *Zoophthora* 161, **170**, 262, 313, 316,
zabri Rozsypal, *Entomophthora* 170,
zabri (Rozsypal ex Ben-Ze'ev et Kenneth) Humber, *Furia* 170,
Zabrus gibbosus (Goeze) 170, 252, 262, 313, 325,
— tenebrioides Goeze 161, 170, 173, 315,
zea (Boddie), Heliothis 119,
Zoopagales 11,
Zoophthora Batko 11, 12, 15, 17, 21, 22, 23, 24, 25, 26, 27, 29, 31, 33, 35, 36, 37, 39, 43, 50, 54, 95, **147**, 148, 153, 160, 171, 172, 179, 181, 184, 208, 211, 214, 215, 226, 227, 228, 229, 231, 233, 236, 237, 243, 244, 245, 259, 265, 267, 284, 285, 287, 289, 290, 303, 310, 318,
— *aleurodis* Bałazy et Manole 175, **176**, 197, 317,
— *americana* (Thaxter) Bałazy ex Humber **162**, 163, 173, 314, 315,
— *anglica* (Petch) Humber 37, 39, 206, **209**, 237, 250, 321,
— *anhuiensis* (Li) Humber 20, 203, **211**, 318,
— *aphidis* (Hoffmann in Fres.) Remaud. et Henneb. 176, 207, **211**, 212, 216, 240, 251, 322, 323,
— *aquatica* (Anderson et Ringo) Bałazy 22, 29, 39, 150, **152**, 311,
— *arginis* Bałazy 16, 204, 214, **217**, 319,
— *athaliae* (Keller) Bałazy 175, **177**, 317,
— *autumnalis* Bałazy 38, 203, 213, **218**, 318,
— *bialoviezensis* Bałazy 38, 206, 213, 215, **219**, 222, 224, 322,
— *blunckii* (Lakon) Batko 175, 177, **178**, 318,
— *brahminae* (Bose et Mehta) Batko 174, **178**, 316,
— *brevispora* Bałazy 38, 204, 215, **221**, 319,
— *bullata* (Thaxter et MacLeod in Humber) Bałazy ex Humber 172, **179**, 180, 315,
— *canadensis* (MacLeod,Tyrrell et Soper) Remaud. et Henneb. 205, 216, **222**, 321,
— *conica* (Nowakowski) Batko 13, 23, 28, 39, 150, **154**, 156, 159, 311,
— *crassispora* Bałazy 38, 206, **223**, 227, 229, 322,
— *crassitunicata* Keller 207, **224**, 323,
— *creatonoti* (Yen in Humber) Batko emend. Bałazy ex Humber 161, **164**, 313,
— *cretonosus* (Yen) Batko 164,
— *curvispora* (Nowakowski) Batko 22, 39, 151, **154**, 159, 312,
— *dacnusae* (Bałazy) Bałazy 175, **183**, 317,
— *delphacis* (Hori) Bałazy ex Humber 174, 180, **183**, 184, 196, 310, 317,
— *delpiniana* (Cavara) Bałazy 150, **155**, 312,
— *dipterigena* (Thaxter) Batko 22, 28, 38, 39, 106, 172, **185**, 189, 192, 315,
— *echinospora* (Thaxter) Batko 16, 29, 38, 145, 172, 179, **185**, 186, 187, 314, 324,
— *elateridiphaga* (Turian) Ben-Ze'ev et Kenneth 210, 237, 250,
— *ellisiana* (Ben-Ze'ev) Bałazy ex Humber 162, **165**, 175, 314, 318,
— *erinacea* Ben-ze'ev et Kenneth 150, **155**, 311,

— *Erynia* (Nowakowski) Batko, subg. 13, 20, 22, 23, 24, 28, 29, 36, 138, 148, **149,** 151, 153, 154, 155, 156, 157, 158, 170, 178, 287,
— *falcata* Bałazy 203, 214, **225**, 319,
— *forficulae* (Giard) Batko 38, 205, 215, **226**, 227, 321,
— *fumimontana* Bałazy 161, **166**, 167, 313,
— *Furia* Batko, subg. 22, 23, 149, **160,** 163, 167, 169, 173, 175, 229,
— *gammae* (Weiser) Bałazy 161, **167**, 313,
— *gastropachae* (Raciborski) Bałazy) 161, **164**, 314,
— *geometralis* (Thaxter) Batko 203, 224, **229**, 318,
— *giardi* Bałazy 38, 205, **230**, 232, 233, 320,
— *gloeospora* (Vuillemin) Batko 173, **191**, 315,
— *gracilis* (Thaxter) Batko 150, **156**, 311,
— *heteropteris* Bałazy 22, 175, **188**, 190, 317,
— *humberi* (Aruta et Carrillo) Bałazy 206, **231**, 321,
— *ichneumonis* Bałazy 38, 204, 227, **231**, 320,
— *ithacensis* (Kramer) Bałazy 38, 160, 173, **191**, 315,
— *kondoiensis* (Milner) Bałazy 174, **195,** 317,
— *lanceolata* Keller 38, 204, 219, 227, **235,** 319,
— *larvivora* Bałazy 207, 215, **235,** 259, 322,
— *lipai* Bałazy, Eilenberg et Papierok 29, 38, 174, 184, **192**, 198, 316,
— *minutospora* (Keller) Bałazy 162, **168,** 314,
— *miridis* Bałazy et Miętkiewski 38, 39, 204, 228, 235, **238**, 239, 320,
— *montana* (Thaxter) Batko 150, **156**, 157, 169, 311,
— *muscivora* (Schroeter) Bałazy 38, 127, 180, 181, 192, **194**, 315,
— *myrmecophaga* Turian et Wuest 37, 38, 175, 180, **188**, 288, 317,
— *nematoceris* Bałazy 38, 39, 204, 208, 235, **240**, 320,
— *neoaphidis* (Remaud. et Henneb.) Bałazy 172, 174, **175**, 176, 189, 196, 216, 317,
— *Neopandora* Ben-Ze'ev et Kenneth, subg. 13, 15, 22, 23, 24, 28, 29, 33, 37, 149, 160, **171**, 177, 178, 181, 182, 184, 187, 197, 199, 216,
— *neopyralidarum* (Ben-Ze'ev) Bałazy ex Humber 161, **168**, 313,
— *nouryi* (Remaud. et Henneb.) Ben -Ze'ev et Kenneth 39, 174, **195**, 196, 216, 317,
— *obtusa* Bałazy 205, 227, **241**, 320,
— *occidentalis* (Thaxter) Batko 22, 206, 212, **242**, 243, 245, 322,
— *opomyzae* Bałazy et Miętkiewski 38, 39, 204, 208, **237**, 319,
— *orientalis* Ben-Ze'ev et Kenneth 205, **243**, 321,
— *ovispora* (Nowakowski) Batko 29, 39, 54, 55, 121, 138, 149, 150, **151**, 152, 153, 159, 312,
— *Pandora* Batko, subg. 171, 178, 185, 191, 196, 201,
— *petchii* Ben-Ze'ev et Kenneth 39, 205, 214, **243,** 321,
— *phalangicida* (Lagerheim) Batko 172, **196**, 197, 314,
— *phalloides* Batko 206, 243, **244**, 245, 322,
— *philonthi* Bałazy 39, 174, **197**, 198, 316,
— *phyllobii* Bałazy 38, 174, 181, **199**, 316,
— *phytonomi* (Arthur) Batko 37, 39, 206, 221, 228, 232, **245**, 269, 322,
— *pieris* (Li et Humber) Bałazy ex Humber 161, **171**, 314,
— *plecopteri* (Descals et Webster) Bałazy 150, **157**, 312,
— *poloniaemajoris* Bałazy 174, **180**, 181, 182, 317,
— *psyllae* Bałazy 204, 214, 235, **247**, 320,
— *radicans* (Brefeld) Batko 39, 147, 205, **207**, 218, 222, 234, 235, 239, 241, 243, 248, 320,
— *rhizospora* (Thaxter) Batko 151, **157**, 312,
— *sciarae* (Olive) Bałazy ex Humber 162, **169**, 314,
— *sepulchralis* (Thaxter) Batko 13, 29, 39, 151, 153, **158**, 312,
— *suturalis* (Ben-Ze'ev) Bałazy 174, 180, **200**, 316,
— *tachypori* Bałazy 38, 203, 211, **248**, 319,
— *variabilis* (Thaxter) Batko 20, 39, 151, 153, **159**, 312,
— *virescens* (Thaxter) Batko 22, 160, 161, **169**, 170, 256, 313,
— *viridis* Keller 206, 210, **249**, 250, 322,
— *vomitoriae* Rozsypal 13, 28, 39, 160, 173, 181, 194, **201**, 315,
— *zabri* (Rozsypal) Bałazy ex Humber 161, **170**, 173, 262, 313, 316,
— *Zoophthora* Batko, subg. 20, 21, 22, 23, 24, 25, 28, 37, 148, 162, **201,**
Zygnemomyces Miura 18, 21, 22, 26, 30, 32, 88, **92**, 285, 286, 301,
— *echinulatus* Miura 17, 19, **92**, 301,
— *pendulatus* (McCulloch) Tucker 92, 302,
Zygomycetes 11, 34, 255, 283,
Zygnomycotina 34, 283,

CONTENTS

Introduction 5
General characteristics 11
Morphology and development 11
Trophic relations 30
Phylogeny 33
Systematics 34
Occurrence and significance 36
Collection, preparation, culturing and storage 40
Abbreviations 45
Index of author's names of fungi 46

Order *Entomophthorales* 49
Family *Basidiobolaceae* 51
Genus *Basidiobolus* 52
Family *Ancylistaceae* 57
Genus *Ancylistes* 58
Genus *Conidiobolus* 60
Subgenus *Conidiobolus* 62
Subgenus *Delacroixia* 75
Subgenus *Capillidium* 83
Genus *Macrobiotophthora* 86
Family *Meristacraceae* 87
Genus *Meristacrum* 88
Genus *Ballocephala* 90
Genus *Zygnemomyces* 92
Family *Entomophthoraceae* 93
Genus *Entomophthora* 95
Genus *Batkoa* 106
Genus *Completoria* 112
Genus *Entomophaga* 113
Genus *Eryniopsis* 130
Genus *Neozygites* 133
Genus *Strongwellsea* 143
Genus *Massospora* 145
Genus *Zoophthora* 147
Subgenus *Erynia* 149
Subgenus *Furia* 160
Subgenus *Neopandora* 171
Subgenus *Zoophthora* 201

Form-genus *Tarichium* 250
References 271
Owadomorkowe – *Entomophthorales* 281
Klucze do oznaczania 293
Glossary 329
Index of Latin names 331

IB PUBLISHER
POLISH ACADEMY OF SCIENCES
W. Szafer Institute of Botany
Lubicz 46, PL-31-512 Kraków, Poland
tel. (012) 21 51 44 fax. (012) 21 97 90

PUBLICATIONS OF THE W. SZAFER INSTITUTE OF BOTANY POLISH ACADEMY OF SCIENCES 1993

ATLASES

• ***Atlas of the Geographical Distribution of Spore Plants in Poland*** (*Atlas rozmieszczenia roślin zarodnikowych w Polsce*). Established in 1962 to present distribution maps of all groups of spore plants in Poland including algae, fungi, lichens, liverworts, and mosses. In 1991 particular series of the „Atlas" have been changed into independant serial works. In this way, the series of mosses has become, since part 8, ***Atlas of the geographical distribution of mosses in Poland***. For every species there is an account of the distribution and ecology in Poland with notes on extra-Polish distribution in English and Polish and generalized distribution maps in the World, Holarctic and Europe. Each part is loose-leaf in folder including ten species. So far maps for 90 species of lichens, 100 species of hepatics, and 50 species of mosses have been published.

Ser. V. Mchy (*Musci*), R. OCHYRA & P. SZMAJDA (Eds.)

		Price US$:
Part 5 (1990)	PL-ISBN:83-232-0330-X	17,00
Part 6 (1990)	PL-ISBN:83-232-0393-8	17,00
Part 7 (1991)	PL-ISBN:83-232-0432-2	17,00
Part 8 (1992)	PL-ISBN:83-232-0393-8	17,00
Part 9 (1993)		17,00

• ***Atlas of the Geographical Distribution of Spore Plants in Poland*** (*Atlas rozmieszczenia roślin zarodnikowych w Polsce*). The series presents lichens distribution maps in Poland. Each species has a bilingual description in English and Polish including the references, full list of localities, and a distribution map. The localities on the maps have been differentiated according to when they were reported (before 1900, from 1901 to 1960, and after 1961). It is planned to publish one or two volumes a year. Each volume will include ten species.

S. CIEŚLIŃSKI, W. FAŁTYNOWICZ (Eds).

		Price US$:
Part 1 (1993)	PL-ISBN:83-85444-24-6	17,00

ICONOGRAPHIES

• ***Flora Polonicae Terrarumque Adiacentium Iconographia*** (*Atlas flory polskiej i ziem ościennych*). Series established in 1930 to present full illustrations and descriptions of all plants growing spontaneously and subspontaneously in Poland and adjacent territories including Lithuania, Byelorussia, the Western Ukraine, and the East Carpathians. Published irregularly in volumes each including a various number of fascicles. Each part is loose-leaf in a folder (in Latin and Polish).

J. MĄDALSKI (Ed.) – *Atlas flory polskiej i ziem ościennych.* Vol. 2, fasc. 5, *Liliaceae* (part 3). *Amarylidaceae, Iridaceae.* Price US$:

PL-ISBN:83-01-08658-0 22,50

BIBLIOGRAPHIES

• ***Botanical Bibliographies*** (*Bibliografie botaniczne*). Published irregularly, this series was established in 1983 to present a full list of publications dealing with all plant groups by Polish botanists as well as all publications covering territory of Poland by foreign authors. So far bibliographies of lichens, fungi, slime moulds, algae and vascular plants have been compiled.

Vol. 3. J. SIEMIŃSKA – *Polish Phycological Bibliography* Price US$: 31,50

Price US$:

Vol. 4. W. STOJANOWSKA – *Polish Bibliography of Slime Moulds (Myxomycetes)*
PL-ISSN:0860–4509 PL-ISBN:83–00–03277–0 12,50

Vol. 5. M. NOWAK – *Polish Bibliography of Vascular Plants (1961–1970)*
PL-ISSN:860–4509 PL-ISBN:83–85444–04–1 17,50

Vol. 6. J. SIEMIŃSKA & J. PAJĄK – *Polish Phycological Bibliography (1981–1990)*
PL-ISSN:860–4509 PL-ISBN:83–85444–08–4 20,00

B. A. THOMAS, H. S. PARDOE & H. E. FRASER – *Bibliography of European Palaeobotany and Palynology (1990–1991)*. (Polish Edition modified and supplemented by E. ZASTAWNIAK). (1993)
Polish edition is to be distributed only in Poland, Czech Republic, Slovakian Republic and Hungary
PL-ISBN:83–85444–15–7 15,00

FLORAS

• ***Flora of Poland, Spore Plants of Poland and Adjacent Territories*** (*Flora polska, Rośliny zarodnikowe Polski i Ziem Ościennych*). Published irregularly since 1957 to present descriptions and illustrations of all species of algae, liverworts, mosses, myxomycetes, fungi and lichens of Poland and adjacent territories. So far one volume of algae, two of mosses, one of liverworts, one of myxomycetes, five of lichens, and eighteen of fungi have been completed (in Polish, English keys).

Price US$:

Grzyby (Mycota)

Vol. 19. A. NESPIAK – Strzępiak (*Inocybe*). (1990)
PL-ISBN:83–01–08749–8 22,50

Vol. 20. A. SKIRGIEŁŁO – Gołąbek (*Russula*). (1991)
PL-ISBN:83–01–09137–1 27,50

Vol. 21. S. DOMAŃSKI – Pucharkowate (*Podoscyphaceae*). (1991)
PL-ISBN:83–01–09471–0 20,50

Vol. 22. H. KWAŚNA, J. CHEŁKOWSKI & P. ZAJKOWSKI – Sierpik (*Fusarium*). (1991)
PL-ISBN:83–85444–00–9 20,50

Vol. 23. W. RUDNICKA-JEZIERSKA – Osiakowate (*Podaxales*). (1991)
PL-ISBN:83–85444–01–7 21,50

Porosty(Lichenes)

Vol. 6., part 3. J. NOWAK – *Physciaceae sensu stricto*. (1993)
PL-ISBN:83–85444–19–X 18,80

• ***Flora of Poland, Vascular Plants of Poland and Adjacent Territories*** (*Flora polska, Rośliny naczyniowe Polski i Ziem Ościennych*). Completed in 14 volumes published in 1919–1980. This flora presents descriptions of all native species and established aliens of vascular plants in Poland and adjacent territories, including Lithuania Byelorussia, the Western Ukraine, and the East Carpathians (in Polish).

Price US$:

[*Flora of Poland. Vascular Plants*] *Flora Polski. Rośliny naczyniowe*
Vol. 3. A. JASIEWICZ (Ed.) (1992)
PL-ISBN:83–85444–06–8 30,00

• ***Field Flora of Fungi*** (*Mała Flora Grzybów*). Published irregularly, this compilation presents descriptions and keys for determination of world fungi species. Seven parts have already appeared (in Polish).

Price US$:

Vol. 1. S. DOMAŃSKI – *Basidiomycetes*: part 6 *Cirticiaceae I, Stephanosporaceae*. (1991)
PL-ISBN:83–01–09859–7 27,50

Vol. 1. S. DOMAŃSKI – *Basidiomycetes*: part 7, *Corticiaceae II*. (1992)
PL-ISBN:83–85444–10–6 28,00

BOOKS

• S. LISOWSKI – ***Les Asteraceae d'Afrique Centrale***, Vol. 1 & 2. *Fragmenta Floristica et Geobotanica* 36(1), Suppl. 1. A taxonomic revision of Central African *Asteraceae* (excl. *Cichorieae, Inuleae* and *Vernonieae*) includes full descriptions of 69 genera and 345 species (of which 121 are illustrated) in two volumes. (1991)

Price US$:

PL-ISSN:0015–931x 50,50

• K. ZARZYCKI, W. WOJEWODA & Z. HEINRICH (Eds.) – ***List of threatened plants in Poland.*** 2nd ed. (*Lista roślin zagrożonych w Polsce, 2 wyd.*) The first edition of *List of threatened plants in Poland* edited by K. ZARZYCKI & W. WOJEWODA was published in 1986. Second edition modified and supplemented contains seven papers with short notes and check-lists of extinct or probably extinct, endangered and vulnerable species of algae, slime moulds, macrofungi, lichens, liverworts, mosses, and vascular plants in Poland. (English summaries). (1992).

Price US$:

PL-ISBN:83–85444–05–X 12,00

• R. OCHYRA & L. STUCHLIK (Eds.) – ***Botanostephane Kornasiana. Botanical Contributions presented to Jan Kornaś in Celebration of His 70th birthday***. A collection of 48 botanical papers in two volumes dealing with taxonomy, phytogeography, ecology, phytosociology and nature protection dedicated to Professor Jan Kornaś.

PL-ISSN:0015–931x PL-ISBN:83–85444–14–9 77,00

• K. ZARZYCKI & R. KAŹMIERCZAKOWA (Eds.) – ***Polish Plant Red Data Book. Pteridophyta and Spermatophyta.*** (*Polska Czerwona Księga Roślin. Paprotniki i Rośliny Kwiatowe*). The Polish Plant Red Data Book covers Pteridophyta and Spermatophyta which are extinct or threatened with extinctionin country. Altogether 206 taxa (10% of vascular flora) were selected. The description of each species comprises: figures of plant, geographical distribution in Poland and in Europe, habitat as well as recommendation for conservation.

PL-ISBN:83–85444–23–8 hard cover 49,00

JOURNALS

• *Acta Palaeobotanica*

A journal published twice a year, established in 1960. It contains research papers concerned with all topics of palaeobotany.

		Price US$:
Vol. 30, No 1, 2 (1990)	PL-ISSN:0001–6594	35,50
Vol. 31, No 1, 2 (1991)	PL-ISSN:0001–6594	35,50
Vol. 32, No 1 (1992)	PL-ISSN:0001–6594	27,00
Vol. 33, No 1 (1993)	PL-ISSN:0001–6594	38,00
Vol. 33, No 2 (1993)	PL-ISSN:0001–6594	20,00

• *Fragmenta Floristica et Geobotanica*

A journal published twice a year, established in 1953. It publishes papers of relevance to the taxonomy, phytogeography, phytosociology, anatomy, biosystematics, cytology, ecology and phytochemistry of all plant groups.

		Price US$:
Ann. 35, Pars 1–2. (1991)	PL-ISSN: 0015–931X	33,00
Ann. 36, Pars 1. (1991)	PL-ISSN: 0015–931X	29,50
Ann. 36, Pars 2. (1991)	PL-ISSN: 0015–931X	29,50
Ann. 37, Pars 1. (1992)	PL-ISSN: 0015–931X	29,00
Ann. 37, Pars 2. (1992)	PL-ISSN: 0015–931X	35,00
Ann. 38, Pars 1. (1993)	PL-ISSN: 0015–931X	36,70
Ann. 38, Pars 2. (1993)	PL-ISSN: 0015–931X	45,00

• *Polish Botanical Studies*

A botanical journal devoted to taxonomy, chorology, ecology, evolution, morphology, anatomy and cytology of all plant groups as well as to palaeobotany. Established in 1990, it publishes original botanical papers including monographs, articles and short communications in English and other congress languages. The journal is issued twice a year and opened to Polish and foreign botanists.

Price US$:

Vol. 1. *Antoni Rehman Festschrift.* (1990)
PL-ISSN:0867–0730 39,50

Vol. 2. *Maria Skalińska Festschrift.* (1991)
PL-ISSN:0867–0730 39,50

Vol. 3. E. ZASTAWNIAK (Ed.) – *The younger Tertiary deposits in the Gozdnica region (SW Poland) in the light of recent palaebotanical research.* (1992)
PL-ISSN:0867–0730 PL-ISBN:83–85444–09–2 30,00

Vol. 4. W. FAŁTYNOWICZ – *The lichens of Western Pomerania (NW Poland), an ecogeographical study.* (1992)
PL-ISSN:0867–0730 PL-ISBN:83–85444–12–2 30,00

Vol. 5. Articles – (1993)
PL-ISSN:0867–0730 PL-ISBN:83–85444 30,00

Vol. 6. W. FAŁTYNOWICZ – *A checlist of Polish lichen forming and lichenicolous fungi including parasitic and saprophytic fungi occurring on lichens.* (1993)
PL-ISSN:0867–0730 PL-ISBN:83–85444 20,00

• *Polish Botanical Studies, Guidebook Series*

Guidebook Series is an irregularly issued supplementary series of *Polish Botanical Studies* intending to publish guides to Polish botanical institutions, collections and collectors, botanical literature, and directories as well as botanical field-guides and basic information regarding various branches of botany.

Price US$:

No 2. Z. MIREK – *Polish Herbaria.* (1990)
PL-ISSN:0867–0749 PL-ISBN:83–00–03272-x 10,50

No 3. M. REYMANÓWNA & A. SKIRGIEŁŁO (Ed.) – *Międzynarodowy Kodeks Nomenklatury Botanicznej.* (in Polish). (1993)
PL-ISSN:0867–0749 PL-ISBN:83–85444–21–1 15,00

No 4. J. SIEMIŃSKA (Ed.) – *Jubilee X Conference of the Phycological Section of the Polish Botanical Society.* (1991)
PL-ISSN:0867–0749 PL-ISBN:83–85444–02–5 12,50

No 5. Z. RADWAŃSKA-PARYSKA – *The Herbarium of Fra Cyprian from the Red Monastery* (in Polish, English summary). (1991)
PL-ISSN:0867–0749 PL-ISBN:83–85444–03–3 15,50

No 6. J. WOŁEK – *Vademecum statystyki dla biologów* (in Polish). (1992)
PL-ISSN:0867–0749 PL-ISBN:83–85444–07–6 15,00

No 7. M. ZAJĄC – *Index of general distribution maps. Vascular plants of Poland.* (1992)
PL-ISSN:0867–0749 PL-ISBN:83–85444–13–0 10,00

No 8. M. RALSKA-JASIEWICZOWA (Ed.) – *Lake Gościąż – progress of studies on the sediments and recent enviroment. Proceeding of the workshop in Gliwice, 30.03. – 02.04.1992.* (in Polish with English summary). (1993)
PL-ISSN:0867–0749 PL-ISBN:83–85444–16–5 17,00

No 9. A. ZEMANEK, B. ZEMANEK (Ed.) – *Studies on the History of Botanical Gardens and Arboreta in Poland.* (1993)
PL-ISSN:0867–0749 PL-ISBN:83–85444–18–1 10.00

No 10. J. SIEMIŃSKA (Ed.) – *International Symposium. Biology and Taxonomy of Green Algae II (Stará Lesná, Slovakia). Postsymposial Excursion to Poland.* (1993)
PL-ISSN:0867–0749 PL-ISBN:83–85444–17–3 10,00

• *Wiadomości Botaniczne (Botanical News)*

A journal is an official review-information quarterly of the Polish Botanical Society. It offers a wide spectrum of publications summarizing and reviewing problems from different branches of botany. Almost a complete survey of current news and events in Polish botany as well as of most important achievements in the world botany may be also found there. Short summaries, titles, and figure descriptions in English make the information available for all foreign botanists.

Price US$:

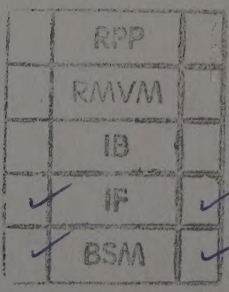
Vol. 34, No. 2; 34, No 3; 34, No 4. (1990)	PL-ISSN:0043–5090	6,00
Vol. 35, No. 1; 35, No 2. (1991)	PL-ISSN:0043–5090	6,00
Vol. 35, No. 3/4. (1991)	PL-ISSN:0043–5090	12,00
Vol. 36, No. 1/2. (1992)	PL-ISSN:0043–5090	12,00
Vol. 36, No. 3/4. (1992)	PL-ISSN:0043–5090	12,00
Vol. 37, No. 1/2. (1993)	PL-ISSN:0043–5090	12,00

To order titles contained in this bulletin, please, write to:

IB Publisher
W. Szafer Institute of Botany
Polish Academy of Sciences
Lubicz 46, 31–512 Kraków
POLAND

Cheques should be made payable to W. Szafer Institute of Botany, Polish Academy of Sciences, Lubicz 46, 31–512 Kraków

Bank: **BPH IV O/M KRAKÓW** Account Nr.: **323415-1502**


RPP
RMVM
IB
IF
BSM

ISBN 83-85444-26-2